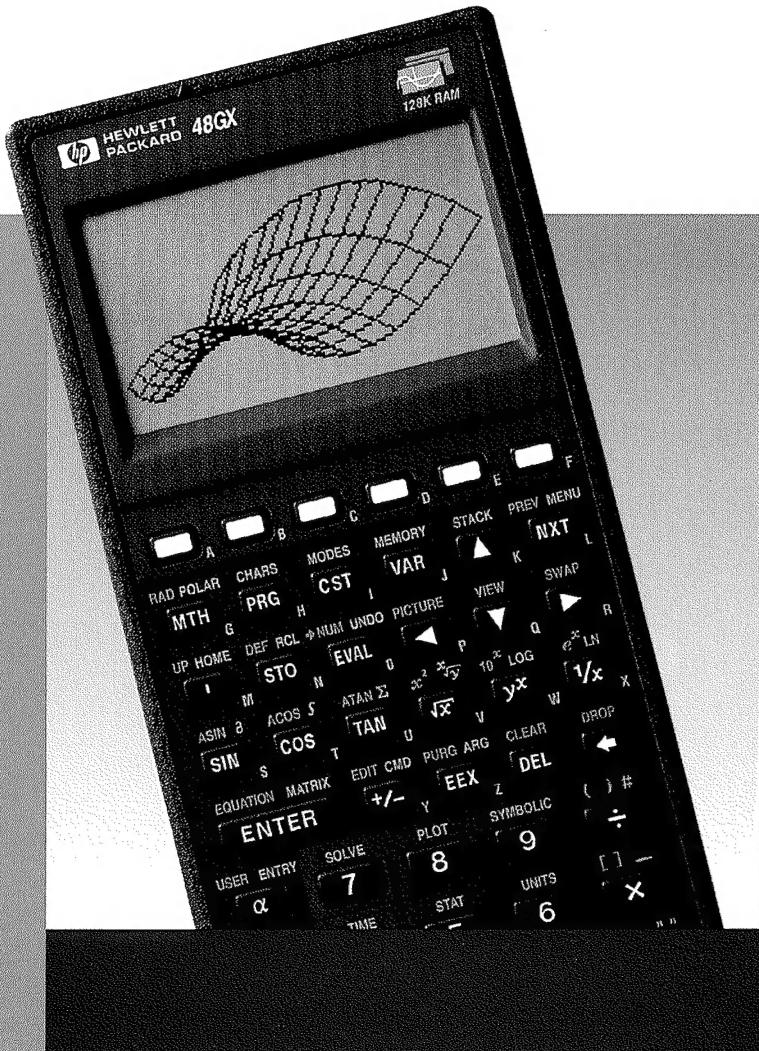**HEWLETT PACKARD**

HP 48G Series
Quick Start Guide

Regulatory Information

U.S.A.

The HP 48 generates and uses radio frequency energy and may interfere with radio and television reception. The HP 48 complies with the limits for a Class B computing device as specified in Part 15 of FCC Rules, which provide reasonable protection against such interference in a residential installation. In the unlikely event that there is interference to radio or television reception (which can be determined by turning the unit off and on), try the following:

- Reorienting or relocating the receiving antenna.
- Relocating the HP 48 with respect to the receiver.

For more information, consult your dealer, an experienced radio/television technician, or the following booklet, prepared by the Federal Communications Commission: *How to Identify and Resolve Radio-TV Interference Problems.* This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 004-000-00345-4. At the first printing of this manual, the telephone number was (202) 783-3238.

Europe

Declaration of Conformity (according to ISO/IEC Guide 22 and EN 45014)

Manufacturer's name: Manufacturer's address:	Hewlett-Packard Co. Corvallis Division 1000 NE Circle Blvd. Corvallis, OR 97330	Hewlett-Packard Co. Singapore (PTE) Ltd. 72 Bendemeer Rd. 01/01-07/07 Singapore 1233
	declares that the following products:	
Product name:	HP 48G Series calculators	
	conform to the following product specifications:	
EMC:	CISPR 22:1985 / EN 55022 (1988): Class B, IEC 801-2:1991 / prEN 55024-2 (1992): 3 kV CD, 8 kV AD, IEC 801-3:1984 / prEN 55024-3 (1991): 3 V/m	
Safety:	IEC 950 (1986)+A1,A2/EN 60950 (1988)+A1,A2	

Quality Department
Hewlett-Packard Company
Corvallis Division

HP 48G Series Quick Start Guide

HEWLETT PACKARD

Notice

Edition History

Edition 1 .... April 1993
Edition 2 .... June 1993
Edition 3 .... August 1993
Edition 4 .... October 1993
Edition 5 .... January 1994

Contents

1

Start Here

Welcome to the community of problem-solvers.

As easy-to-use as a calculator. The HP 48G Series calculators use a special graphical interface, inspired by current generations of desktop computer software. This interface guides you through your problem-solving applications smoothly and quickly. Whether you are solving simultaneous equations, plotting parametric equations, symbolically solving an integral, or analyzing a set of data, both HP 48 models work in a familiar, intuitive way—performing tasks and producing readable results.

As powerful as a computer. The HP 48G Series calculators come with 512K of built-in ROM and up to 128 KBytes of built-in RAM. All HP 48 models offer you the problem-solving power of specialized computer software costing hundreds of dollars—handheld power that you can take with you wherever you need it. The HP 48 family comes with memory management tools, a structured programming language, and extensive input/output capabilities—all characteristic of full-size computers.

About the Quick Start Guide

The *HP 48G Series Quick Start Guide* is designed to help you learn how to use the HP 48. It is organized into lessons, each of which guides you through a series of examples that illustrate how to accomplish some task. Lessons are grouped into chapters.

The *HP 48G Series Quick Start Guide* doesn't provide an example for every feature of the HP 48. But it should provide you with the understanding and confidence to explore the nooks and crannies for yourself. Please refer to the *HP 48G Series User's Guide* if you want to explore an application in greater detail.

Here are some suggestions:

- *Read lesson 1 first.* It shows you how to set up the machine so that the rest of lessons in the machine will work smoothly. After this, explore the lessons in any order you find convenient.

- *Try the examples.* They'll give you a good idea of how you can use the HP 48. Actually pushing the keys and watching the HP 48 work while following along is the fastest, easiest way to learn.

  Occasionally, an individual example will build on the results of a previous calculation or example. (This is especially true for parameters in the application environments, such as PLOT or SOLVE.) If you notice that the screen of your HP 48 doesn't match the screen shown in the example, simply correct your screen and then continue with the keystrokes given in the example.

- *Don't panic.* You can turn the HP 48 off at any time—when you turn it on again, it'll be ready to continue where you left off. If you run into trouble, see chapter 10, "If Things Go Wrong," at the end of this manual.

Lesson 1: Getting Ready

Here are a few things to do to prepare the HP 48 before you begin.

Turning the HP 48 On and Off

▶ Press (ON) to turn the machine on. (The (ON) key is highlighted in the diagram at the right.)

▶ Press ⟦→⟧ (OFF) to turn it off. The (OFF) key is a *shifted* version of the (ON) key (the green ⟦→⟧ shift).

The calculator will also turn itself off if you haven't used it for 10 consecutive minutes in order to preserve its batteries. Unlike some calculators (or computers) you may have used, the HP 48 can be turned off at any time without risking data loss.

Adjusting the Display Contrast

▶ With the calculator on, hold down the (ON) key and press (+) (to darken) or (−) (to lighten) the display.

Preparing the Built-In Examples

1. Hold down (α) (highlighted in the diagram at the right) and while holding it, press (in sequence) (COS)T, (☐)E, (☐)A, (☐)C, (PRG)H so that you type in the word TEACH at the bottom of the display. When finished, release the (α) key.

2. Press (ENTER).

The TEACH command resets the calculator modes to their default values and loads a number of example functions, data sets and other objects that are used in some of the examples in the *HP 48G Series Quick Start Guide* and the *HP 48G Series User's Guide*.

Whenever you wish to remove all of the objects that TEACH created: type CLTEACH (holding down the (α) key as in the example above) and then press (ENTER).

Setting the Time and Date

1. Open the TIME application, choose
   Set time and date:
   ⏎ (TIME) (▲) OK .

```
▓▓▓▓▓▓▓SET TIME AND DATE▓▓▓▓▓▓▓

TIME:   █9:45:57  AM
DATE:    1/ 3/94  M/D/Y

ENTER HOUR
▐EDIT▌CHOOS▌▬▬▬▬▬▬▬▐CANCL▐OK▌
```

2. Type the hour, minutes, and seconds, pressing (ENTER) after each.
3. (optional) If you want the clock to report the time using 24-hour format, press (+/−) until 24-hr is displayed.
4. Press (▶) to advance the highlight and then type the day, month, and year, pressing (ENTER) after each.
5. (optional) If you want the clock to report the date using day-month-year format, press (+/−) until D.M.Y is displayed.
6. Press OK , once everything is set as you wish.

Setting the Beeper, Clock, and Fraction Mark

1. Open the MODES utility:
   ⏎ (MODES)

```
▓▓▓▓▓▓▓CALCULATOR MODES▓▓▓▓▓▓▓
NUMBER FORMAT:█Std█
ANGLE MEASURE: Degrees
COORD SYSTEM:  Rectangular
✓BEEP   _CLOCK  _FM.

CHOOSE NUMBER DISPLAY FORMAT
▬▬▬▐CHOOS▌▬▬▬▐FLAG▐CANCL▐OK▌
```
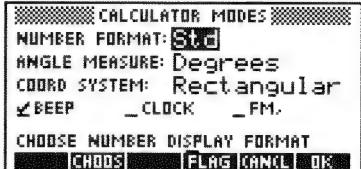
2. (optional) If you want to turn the beeper *off*, move the cursor to the BEEPER field, and press ✓CHK so that the check-mark disappears.
3. (optional) If you want to continuously display the date and time on the main calculator screen, move the cursor to the CLOCK field and press ✓CHK so that the check-mark appears.
4. (optional) If you want to use the comma instead of a decimal point as the fraction mark, move the cursor to the FM field and press ✓CHK so that the check-mark appears.
5. Once you have set the options as you wish, press OK .

2

Introducing the HP 48

This chapter provides a brief introduction to the HP 48—an overview of its design, operating fundamentals, and far-ranging mathematical power. Specifically, you will learn how to:

▶ Use the stack and command line.

▶ Enter mathematical objects (numbers, equations, matrices, units).

▶ Enter text, including non-English and mathematical characters.

▶ Correct input errors and edit objects.

▶ Use menus and navigate within them.

▶ Explore the various user-friendly environments of the HP 48.

Lesson 2: Mathematical Objects and the HP 48

The mathematical and scientific disciplines use a wide variety of objects in the process of describing and solving problems: real numbers (sometimes with units attached), complex numbers, vectors, matrices, functions, variables, equations, plots of many kinds, points, sequences, words and sentences, programs, and so forth.

The HP 48 can use all of these objects and more:

Concept	Example	HP 48 Object
Real Number	14.75	14.75
... with Unit	14.75 m/s	14.75_m/s
Complex Number	$3 + 4i$	(3,4)
... Polar Form		(5,∠53.1)
Ordered Pair	(4,-6)	(4,-6)
Coordinate	(8.25,12.1)	(8.25,12.1)
Symbolic Constant	π	'π'
Variable	x	'x'
Vector	$4i + j - 3k$	[4 1 -3]
... Polar Form		[5 ∠40 ∠126]
Matrix	$\begin{bmatrix} 3 & -4 & 1 \\ 0 & 1 & -2 \end{bmatrix}$	[[3 -4 1] [0 1 -2]]
Text String	Begin here.	"Begin here."
Labeled Quantity	Volume is 6.74 ml.	VOL: 6.74_ml
Equation	$4x^3 - 5xy^2 = 9x + y$	'4*x^3-5*x*y^2= 9*x+y'
Expression	$\sin(x)$.	'SIN(x)'
Sequence	0,1,1,2,3,5	{ 0 1 1 2 3 5 }
Commands	Draw the plot.	DRAW
Program	Find square roots.	« √ DUP NEG »
List	2, "TWO", DRAW	{ 2 "TWO" DRAW }

By design, the HP 48 makes it easy to move between one type of object and another as one solves a problem, explores data, or communicates results. It accomplishes this by using an *object stack* (or "stack," for short).

Envision the stack as a special kind of "card box" in which the HP 48 organizes all of the objects it uses in the course of calculating, solving, plotting, and evaluating.

Each object, no matter its size, occupies exactly one "card" in the "card box." The object on the first "card" is said to be on "stack level 1," the object on the second card is on "stack level 2," and so forth. The stack can contain any number of objects—from zero to as many as available memory permits.

The main display of the HP 48 is the *stack display*. It is merely a window showing you a portion of the stack at a time.
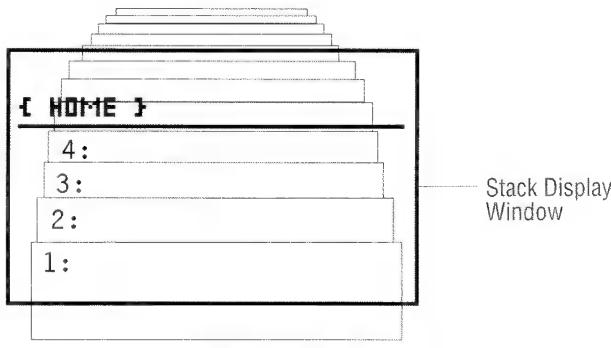
Envisioning the Stack

Objects enter and "leave" the stack at level 1. When you enter a new object, you place it in the front of the "card box" (stack level 1) thereby pushing objects already in the "box" farther to the back (increasing their stack levels each by one in the process).

Example: Enter some objects onto the stack: 39.3, { 1 2 4 8 }, (4,5), 7, .99479.

Step 1: Enter the first number.

39.3 (ENTER)

```
{ HOME }
4:
3:
2:
1:                          39.3
VECTR MATR LIST HYP REAL BASE
```

Step 2: Type the delimiters ({}) for the list.

⬅️ ({})

```
1:                          39.3
{}
VECTR MATR LIST HYP REAL BASE
```

Step 3: Type in the contents of the list, separating each with a space.

1 (SPC) 2 (SPC) 4 (SPC) 8

```
1:                          39.3
{1 2 4 8}
VECTR MATR LIST HYP REAL BASE
```

Step 4: Enter the list.

(ENTER)

```
2:                          39.3
1:                   { 1 2 4 8 }
VECTR MATR LIST HYP REAL BASE
```

Step 5: Enter the remaining objects.

⬅️ () 4 (SPC) 5 (ENTER)
7 (ENTER)
.99479 (ENTER)

```
{ HOME }
4:                   { 1 2 4 8 }
3:                         (4,5)
2:                             7
1:                        .99479
VECTR MATR LIST HYP REAL BASE
```

Editing an Object in the Command Line

You probably noticed that as soon as you begin typing in an object, it appears "below" the stack on a line of its own. This line is the *command line*. Actually, the command line is more than one line. It expands as needed to accommodate objects of any size. Objects in the process of being created stay on the command line until you press (ENTER), at which point they are placed onto the stack and the command line disappears.

Making typing errors while creating numbers and other objects is a common problem, but one that is easily fixed. After all, the command line is designed to be a preliminary work area where you can create, edit, or refine an object before you decide to enter it, thus declaring it "ready."

As long as you see the command line, you can edit whatever you're in the process of creating. Here's a list of the editing keys and what they do:

(CANCEL) Erases the entire Command Line, causing it to disappear until you start typing again.

(◄) Moves the cursor (✦) to the left.

(►) Moves the cursor to the right.

(▲) Moves the cursor to the line above (for objects requiring more than one line).

(▼) Moves the cursor to the line below (for objects requiring more than one line).

(◄) Erases the character to the left of the cursor.

(DEL) Erases the character underneath the blinking cursor.

Each of these keys are editing keys *only while you are using the command line*. At other times, each key performs the action printed above it. When there's no command line, (◄) becomes (DROP), (DEL) becomes (CLEAR) and so forth. This allows you quicker access to these operations (you need not press the (◄) shift key first).

Removing Objects from the Stack

Example: Now remove ("drop") objects from the stack.

Step 1:   Drop just the object in level 1. Notice that all other objects drop a level in the process.

(DROP)

```
{ HOME }
4:                        39.3
3:            { 1 2 4 8 }
2:                       (4,5)
1:                           7
VECTR MATR LIST HYP REAL BASE
```
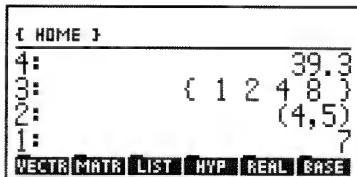
Step 2:   Clear all objects from the stack.

(CLEAR)

```
{ HOME }
4:
3:
2:
1:
VECTR MATR LIST HYP REAL BASE
```
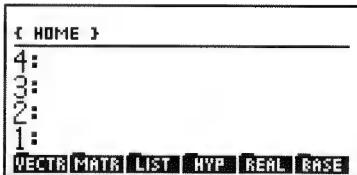
Step 3:   Oops! You are not sure that you really wanted to do that last (CLEAR). Restore the stack to the way it was before the last operation.

(⮐) (UNDO)

```
{ HOME }
4:                        39.3
3:            { 1 2 4 8 }
2:                       (4,5)
1:                           7
VECTR MATR LIST HYP REAL BASE
```
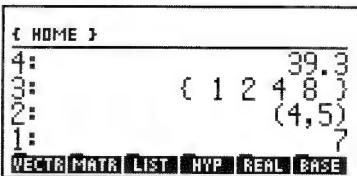
Step 4:   After reviewing the stack objects again, you decide that you were right the first time. Press (CLEAR)

Lesson 3: Entering Characters

There are over 200 characters available on the HP 48. They can be used in text strings and, with a few restrictions, in variable names and equations. Most of these characters are available on the Alpha ($\boxed{\alpha}$) keyboard, and all are accessible using the CHARS feature.

The $\boxed{\alpha}$ Keyboard
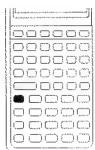
The $\boxed{\alpha}$ key is a special shift key that converts the keyboard into a kind of typewriter. Whenever you see the α annunciator at the top of the display, the next key you press will type its alpha character instead of performing its operation.

Only the upper-case English letters are printed on the keyboard (in white at the lower-right corner of the respective key).

You can turn on the α annunciator (that is, enter *alpha mode*) several ways, depending on what is most convenient for you:

$\boxed{\alpha}$	Enters alpha mode for the next keystroke only.
$\boxed{\alpha}\boxed{\Leftarrow}$	Enters lowercase ($\boxed{\Leftarrow}$) alpha mode for the next keystroke only.
$\boxed{\alpha}\boxed{\Rightarrow}$	Enters extended ($\boxed{\Rightarrow}$) alpha mode for the next keystroke only.
$\boxed{\alpha}\boxed{\alpha}$	Locks alpha mode on until you press $\boxed{\alpha}$, $\boxed{\text{ENTER}}$, or $\boxed{\text{CANCEL}}$.
$\boxed{\alpha}$-(hold)	Enters alpha mode for as long as you hold the $\boxed{\alpha}$ key down. You can press other keys meanwhile.
$\boxed{\alpha}\boxed{\alpha}\boxed{\Leftarrow}\boxed{\alpha}$	Locks lower-case alpha mode on until you press $\boxed{\alpha}$, $\boxed{\text{ENTER}}$, or $\boxed{\text{CANCEL}}$.

Some examples of the alpha keyboard are shown below:

$\boxed{\alpha}$ A $\boxed{\alpha}$ B $\boxed{\alpha}$ C	➜ ABC
$\boxed{\alpha}$-(hold) A B C (release)	➜ ABC
$\boxed{\alpha}\boxed{\alpha}$ A B C $\boxed{\alpha}$	➜ ABC
$\boxed{\alpha}$ A $\boxed{\alpha}\boxed{\Leftarrow}$ B $\boxed{\alpha}$ C	➜ AbC
$\boxed{\alpha}$-(hold) A $\boxed{\Leftarrow}$B C (release)	➜ AbC
$\boxed{\alpha}\boxed{\alpha}$ A $\boxed{\Leftarrow}$B C $\boxed{\alpha}$	➜ AbC
$\boxed{\alpha}\boxed{\alpha}\boxed{\Leftarrow}\boxed{\alpha}$ A B C $\boxed{\alpha}$	➜ abc

Special Characters
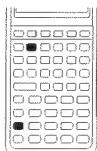
The CHARS feature allows you to find any character and put it into the command line as if you had typed it from the keyboard. Press 🠒 [CHARS] and go exploring.

The 256 characters are collected into screens of 64 characters each:


```
::::::::::CHARACTERS 0-63::::::::::
█■■■■■■■■■■■■■■■
■■■■■■■■■■■■■■■■…
 !"#$%&'()*+,-./
0123456789:;<=>?
KEY: (NONE)              NUM: 0
▇▇▇▇▇▇▇▇▇▇ -64 +64 ECHO
```

```
::::::::::CHARACTERS 64-127::::::::::
@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[\]^_
`abcdefghijklmno
pqrstuvwxyz{|}~▒
KEY: α→[ENTER]           NUM: 64
▇▇▇▇▇▇▇▇▇▇ -64 +64 ECHO
```

```
::::::::::CHARACTERS 128-191::::::::::
█x̄∇∫∫Σ▶π∂≤≥≠α→←↓
↑γδ∈ηθλρστωΔΠΩ■∞
¡¢£¤¥¦§¨©ª«¬-®¯
°±²³´µ¶·¸¹º»¼½¾¿
KEY: ←[SPC]              NUM: 128
▇▇▇▇▇▇▇▇▇▇ -64 +64 ECHO
```

```
::::::::::CHARACTERS 192-255::::::::::
ÀÁÂÃÄÅÆÇÈÉÊËÌÍÎÏ
ÐÑÒÓÔÕÖ×ØÙÚÛÜÝÞß
àáâãäåæçèéêëìíîï
ðñòóôõö÷øùúûüýþÿ
KEY: αΛα←↑7              NUM: 192
▇▇▇▇▇▇▇▇▇▇ -64 +64 ECHO
```
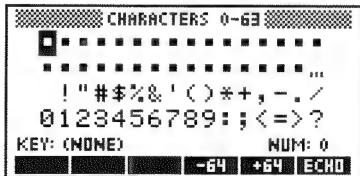
Move around in CHARS. Press -64 or +64 to switch between the four screens. Press the arrow keys to move the cursor around within a screen. Notice that the alpha keyboard equivalents for the highlighted character are displayed next to KEY: at the bottom of the display.

Once you've highlighted a desired character, pressing ECHO places the highlighted character in the command line. Press (CANCEL) to exit the CHARS feature.

Lesson 4: Using Menus

The HP 48 employs 49 keys to access over a thousand operations. This greatly extended keyboard is due primarily to the use of *menus*.

A menu is a set of operations defined for the six white *menu keys* on the top row of the keyboard. The current operations are described by the six *menu labels* on the bottom row of the display.
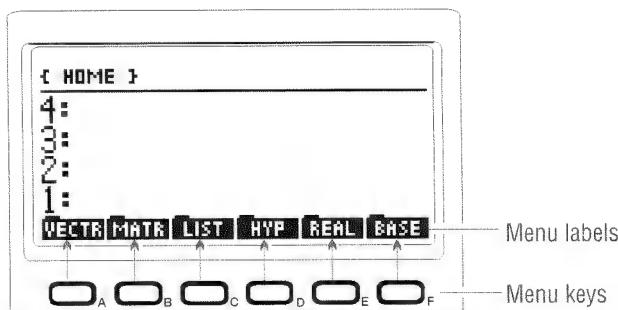
Some menu labels are displayed with a small "tab" attached to the top left-hand side of the label. These "tabbed" operations do not act on data; they are navigational, simply leading to a different menu or application.

The (NXT) Key

Menus often contain more than six operations. When they do, they have multiple "pages." The (NXT) key brings up the next page of the current menu. Pressing (←)(PREV) brings up the previous page of the current menu.

Occasionally, you will want to quickly oscillate between two different menus. Pressing (→)(MENU) brings up the menu displayed immediately before the current one.

Lesson 5: A Brief Tour of the HP 48

As compact and powerful as the stack is for manipulating objects, there are many kinds of problem-solving situations which demand special working environments tailored to specific needs. This lesson takes you on a short tour of the various user-friendly environments that comprise the HP 48.

Entry Environments

You have already seen the main entry environment on the HP 48—the command line. However, among the mathematical objects handled by the HP 48 are objects whose natural format is not well-suited to the command-line display.

Creating Equations: 🔲 EQUATION
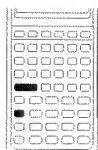
Algebraic equations and expressions can be entered as you are accustomed to seeing them using a special entry environment, the *EquationWriter*. The EquationWriter is handy for writing any equation in a familiar form (see lesson 6 for a worked example).

Samples:

$$8 \left(\frac{5 + \frac{6}{19}}{5 - \frac{6}{19}} \right) - 7 \left(\frac{1 + \frac{1}{4}}{1 - \frac{1}{4}} \right)$$

$$2 + \frac{x^2 + 1}{\sqrt{x^2 + 5}}$$

$$2\pi \int_0^h \frac{rx}{h} \sqrt{1 + \frac{r^2}{h^2}} \, dx$$

Creating Matrices: 🠔 MATRIX
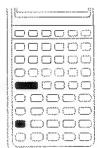
You can also enter a matrix in a form similar to its depiction in books—using the special *MatrixWriter* entry feature. It can create either real or complex matrices. Lessons 20 and 34 contain worked examples using the MatrixWriter.

Samples:

$$\begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$$
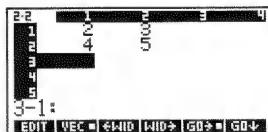
$$\begin{bmatrix} 2 \\ 3 \\ 4 \\ 5 \end{bmatrix}$$

$$\begin{bmatrix} 3 - i & -2 + 2i \\ -6 & 4 + 7i \end{bmatrix}$$
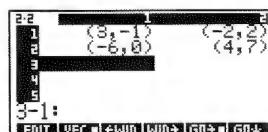
Creating Pictures: ◄⟵ PICTURE
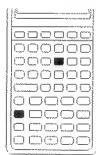
PICTURE provides access to the HP 48 graphics "blackboard" (called *PICT*). Graphs are plotted and freehand drawings are created and displayed on this blackboard. See chapter 6 of this guide or chapters 22-24 of the *HP 48G Series User's Guide* for more about plotting. See chapter 9 of the *HP 48G Series User's Guide* for more about freehand drawing.

Samples:
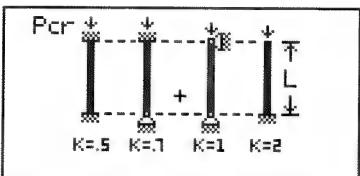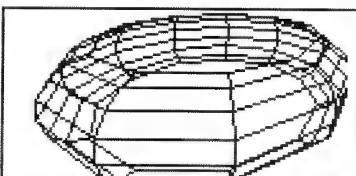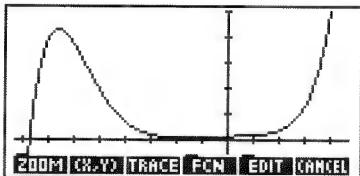
Application Environments

Each of these applications facilitates your interaction with a particular kind of problem or activity. Some use *input forms* and *choose lists* that prompt you for the necessary information and conveniently display your options. To peek at an application, press the appropriate keys; to exit from a form or list to the stack display, press (CANCEL).

Solving Equations: ➡

The choose list in SOLVE allows you to select the kind of problem that you want to solve.
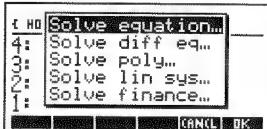
Plotting Functions: 🠮 PLOT

PLOT allows you to select any one of 15 plot types. The input form you see adjusts to show the options available for your selected plot type.

```
▒▒▒▒▒▒▒PLOT▒▒▒▒▒▒▒
TYPE: Function    ⋖:Deg
EQ:
INDEP: X    H-VIEW: -6.5 6.5
_AUTOSCALE  V-VIEW: -3.1 3.2
ENTER FUNCTION(S) TO PLOT
EDIT CHOOS      OPTS ERASE DRAW
```
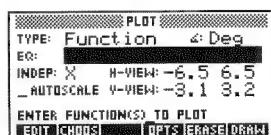
Symbolic Math: 🠮 SYMBOLIC

The SYMBOLIC application contains special calculus tasks as well as general purpose symbolic manipulation.

```
{ HO Integrate...
4: Differentiate...
3: Taylor poly...
2: Isolate var...
1: Solve quad...        ↓
                  CANCL  OK
```
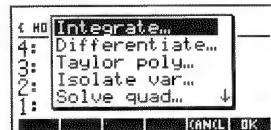
Time Management: 🠮 TIME

You already used TIME in the first lesson to set the time and date. You can also use alarms to help manage your time.

```
{ HOME }
4: Browse alarms...
3: Set alarm...
2: Set time, date...
1:
                  CANCL  OK
```
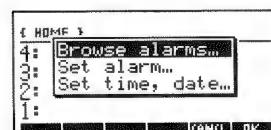
Statistics and Data Analysis: 🠮 STAT

The STAT application allows you to enter data into a matrix and to collect descriptive statistics or run a regression on it.

```
{ HO Single-var...
4: Frequencies...
3: Fit data...
2: Summary stats...
1:
                  CANCL  OK
```
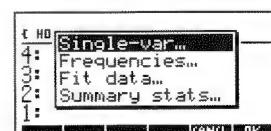
Unit Management: 🠮 UNITS

UNITS allows you to attach any of over 100 units to real numbers. The HP 48 can keep track of units during calculations.

```
{ HOME }
4:
3:
2:
1:
LENG AREA  VOL  TIME SPEED MASS
```
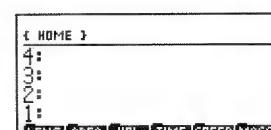
Printing and Data Transfer: ⮕
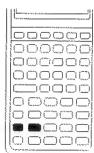
The I/O application allows you to print objects or to transfer data between two HP 48s or between the HP 48 and a computer.

```
{ HO  Send to HP 48…
4:    Get from HP 48
3:    Print display
2:    Print…
1:    Transfer…        ↓
                    CANCL  OK
```

Using External Programs: ⮕
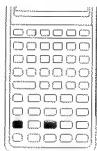
The LIBRARY application helps you manage and retrieve external programs and other objects stored on plug-in cards or in backup memory.

```
{ HOME }
4:
3:
2:
1:
```
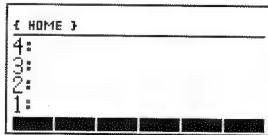
Using Built-In Equations: ⮕
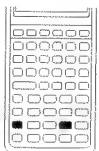
The EQ LIB application allows you to select from over 300 built-in equations and use them to solve problems.

```
EQUATION LIBRARY
Columns and Beams
Electricity
Fluids
Forces and Energy
Gases
Heat Transfer          ↓
SI ■ ENGL UNIT ■        QUIT
```
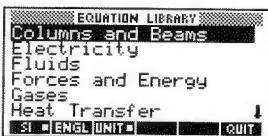
Utility Environments

There are four special interactive environments that help you to manage and organize your work and control the way your calculator functions. You will use these environments independently and in combination with the applications.

Editing Previously-Created Objects: ⬅ EDIT
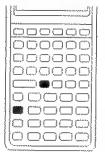
The EDIT environment is an expanded version of the command line and is used to edit objects after they've been entered onto the stack.

```
                        ALG PRG
{ HOME }

◆6/(X^2-9)+4/(6+X-X
^2)+2/(X^2+5*X+6)'
◄SKIP SKIP► ◄DEL DEL► INS ■↑STK
```
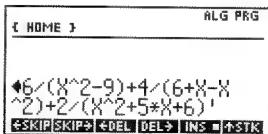
Setting Calculator Modes: ⟦→⟧ MODES
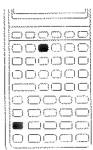
You visited MODES in lesson 1.
It is used to set the various
calculator modes and to change
flag settings.

```
▓▓▓▓▓ CALCULATOR MODES ▓▓▓▓▓
NUMBER FORMAT: Std
ANGLE MEASURE: Degrees
COORD SYSTEM: Rectangular
✓BEEPER  _CLOCK   _FM∠
CHOOSE NUMBER DISPLAY FORMAT
 CHOOS      FLAG CANCL OK
```
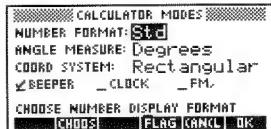
Storing, Retrieving, and Organizing Variables: ⟦→⟧ MEMORY
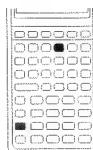
MEMORY allows you to name,
store, view, retrieve, purge and
rearrange any objects stored in
your user memory.

```
▓OBJECTS IN { HOME EXAMPLES }▓
PRGS: DIR MEDIAN «...
PLOTS: DIR XSIN « R...
EQNS: DIR ONE 'SIN(...
%TILE: « SWAP SORT ...
PURGEX: « HOME 'EXA...
EDIT CHOOS ✓CHK NEW COPY MOVE
```

Viewing and Organizing Objects on the Stack: ⟦→⟧ STACK
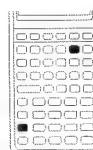
STACK allows you to view and
manipulate the objects in
temporary storage on the stack.

```
{ HOME }
4:                          5
3▶ '6/(X^2-9)+4/(6+X-...
2:              'COS(5*θ)'
1:                      (5,6)
ECHO VIEW PICK ROLL ROLLD ▷LIST
```

3
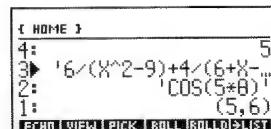
Arithmetic

This chapter shows you how to:

▶ Calculate using real numbers.

▶ Calculate using fractions.

▶ Calculate using symbolic variables.

▶ Calculate using complex numbers.

▶ Calculate using units.

Lesson 6: Doing Arithmetic

There are actually two different ways that you can "do" arithmetic on the HP 48. The stack method is most convenient when you want to perform immediate calculations involving one or more numbers. The algebraic method is most convenient when you wish to describe your calculation as a formula (so that you can verify it or reuse it) before evaluating it.

Stack Method

Look at an example of the way the stack works during a calculation. It works very much like the pencil-and-paper arithmetic taught in elementary school. For example, to find the difference of two numbers (such as 8.9 and 7.2), you first write them both onto the paper and *then* subtract:

$$
\begin{array}{r}
8.9 \\
-\ 7.2 \\
\hline
1.7
\end{array}
$$

Using the stack for arithmetic on the HP 48 exactly mirrors the manual process. Enter the numbers (or *arguments*) first, then perform the operation.

Example: Subtract 7.2 from 8.9 on the HP 48.

Step 1:   Enter the numbers. Notice that you enter numbers in the same order that you would write them on paper.

8.9 (ENTER) 7.2 (ENTER)

```
2:                    8.9
1:                    7.2
VECTR MATR LIST HYP REAL BASE
```

Step 2:   Perform the subtraction. The subtraction operation removes the objects on the first two stack levels (noting the order) and returns the difference back to level 1.

⊟

```
1:                    1.7
VECTR MATR LIST HYP REAL BASE
```

This process of entering numbers onto the stack and using numbers from the stack during calculations underlies everything the HP 48 does. This approach makes it easy for the calculator to work very efficiently because the results of one calculation are left sitting on the top of the stack ready to be used by any other command.

Example: Divide the previous result by 1.3. The numerator—the result of the previous calculation—is already entered, so you only need to enter the denominator and divide.

1.3 (ENTER) (÷)

```
1:              1.30769230769
VECTR MATR LIST HYP REAL BASE
```

The next few examples use a keystroke-saving shortcut that you haven't seen yet. When calculating with the stack, "mathematical" keys, such as (+), causes an automatic (ENTER) before it executes its action. This allows you to use the sequence, 8.9 (ENTER) 7.2 (−) instead of 8.9 (ENTER) 7.2 (ENTER) (−), to subtract 7.2 from 8.9. In short, it saves you a keystroke.

Work the following short examples of stack arithmetic that use the fourth-row mathematical keys. Notice in particular how each operation leaves the results ready for the next operation.

Example: Calculate $\frac{1}{62.5}$.

(CLEAR) 62.5 (1/x)

```
1:                      .016
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate 20^{-2}.

(CLEAR) 20 (ENTER) 2 (+/−) (y^x)

```
1:                     .0025
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate $4e^{2\sqrt{5}}$.

(CLEAR) 4 (ENTER) 2 (ENTER) 5
(√x) (×) (◄) (e^x) (×)

```
1:              350.174049835
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate $\frac{15}{.06 \times 14.5}$.

15 (ENTER)
.06 (ENTER) 14.5 (×) (÷)

```
1:            17.2413793103
VECTR MATR LIST HYP REAL BASE
```

Algebraic method

The HP 48 is as proficient with algebraic arithmetic as it is with
stack arithmetic. Unlike the direct, immediate approach of stack
arithmetic, the HP 48 also allows you to enter a computation as an
algebraic formula so that you can inspect it or store it for later use.
This method also has two steps: first create and enter the formula,
then evaluate it to compute the result.
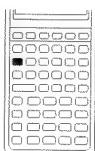
You must surround an algebraic formula with
tick-marks (' ') so that the HP 48 understands that you
want to treat the mathematical operations as a formula
instead of as a series of direct commands. The "tick" key
((')) is highlighted in the diagram to the left.

Example: Calculate $\frac{1}{62.5}$ using the algebraic method.

Step 1:   Enter the algebraic expression.

(') 1 (÷) 62.5 (ENTER)

```
1:                   '1/62.5'
VECTR MATR LIST HYP REAL BASE
```

Step 2:   Evaluate the expression to obtain a numerical result.

(EVAL)

```
1:                       .016
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate 20^{-2}.

(CLEAR) (') 20 (y^x) (+/−) 2 (EVAL)

```
1:                      .0025
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate $4e^{2\sqrt{5}}$.

(CLEAR) (') 4 (×) (⇦) (e^x) 2 (×)
($\sqrt{x}$) 5 (EVAL)

```
1:             350.174049835
VECTR MATR LIST HYP REAL BASE
```

Example: Calculate $\frac{15}{.06 \times 14.5}$.

(CLEAR) (') 15 (÷) (⮪) (()) .06
(×) 14.5 (EVAL)

```
1:              17.2413793103
VECTR MATR LIST  HYP  REAL BASE
```

Using the EquationWriter

When the equations or calculations get more complicated, the
HP 48 offers a special way to enter algebraic expressions—the
EquationWriter. You don't use tick-marks in the EquationWriter
because *everything* you create there is an algebraic. Try some
examples to see how it works.

Example: Repeat the previous example using the EquationWriter.

Step 1:   Call up the EquationWriter and enter the equation.

(⮪) (EQUATION)
15 (÷) .06 (×) 14.5

```
   15
 ──────
 .06·14.50



VECTR MATR LIST  HYP  REAL BASE
```

Step 2:   Evaluate the expression.

(EVAL)

```
1:              17.2413793103
VECTR MATR LIST  HYP  REAL BASE
```

Example: Using the EquationWriter, find a real number
           approximation for the following expression:

$$\left(1 + \sqrt{\dfrac{2}{1 + \sqrt{\dfrac{3}{1 + \sqrt{\dfrac{5}{3 + \sqrt{7}}}}}}} \right) \dfrac{3^{\frac{2}{3}} + 4}{11}$$

Step 1:   Create the large parenthetical expression.

Step 2:   Advance the cursor until it is outside of the closing
          parenthesis. Currently, it is "buried" within layers of
          subexpressions—square roots and quotients.

▶ (8 times)
(or ⮕ ▶ as a shortcut)

Step 3:   Finish entering the expression. Notice that you begin a
          numerator with more than one term by using the ▲ key.
          The formula is displayed on stack level 1 in its "one-line"
          form, which is the form in which you must enter it *if you
          didn't have the EquationWriter to help you.*

× ▲ 3 yˣ 2 ÷ 3
▶ ▶ + 4 ▶ (or ▼) 11
ENTER

1: '(1+√(2/(1+√(3/(1+√
   (5/(3+√7))))))*((3
   ^(2/3)+4)/11)'

Step 4:   Make a copy of the expression by "entering" it again. Then
          evaluate the copy.

ENTER
EVAL

2: '(1+√(2/(1+√(3/(1+...
1:         1.07464811427

Lesson 7: Finding and Using More Math Functions

The HP 48 has many more math functions than can be fit onto the keyboard—even using the two shift-keys. The others are collected and organized into menus that you can access using the (MTH) key in the second-row of the keyboard.

Example: Find 15 percent of 145. The % command is in the MTH REAL menu.

Step 1:   Clear the stack and enter 145 and 15. Then get the MTH menu.

(CLEAR)
145 (ENTER) 15
(MTH)

```
1:                    145
15◄
VECTR MATR LIST HYP REAL BASE
```

Step 2:   Get the REAL submenu, find the % command, and calculate 15% of 145.

REAL   %

```
2:
1:                 21.75
  %  %CH %T MIN MAX MOD
```

Example: Find 6! (6 factorial). The ! command is in the probability (MTH PROB) menu.

Step 1:   Clear the stack and key in 6. Then get the MTH PROB menu.

(CLEAR)
6 (MTH) (NXT) PROB

```
1:
6◄
COMB PERM ! RAND RDZ
```

Step 2:   Execute the ! command to find 6!.

!

```
2:
1:                   720
COMB PERM ! RAND RDZ
```

Lesson 8: Arithmetic with Fractions

Fractions—whether they are proper, improper, or mixed—can be represented on the HP 48 as algebraic expressions. Use the EquationWriter to enter fractions.

Example: Add $\frac{5}{12}$ and $1\frac{3}{4}$.

Step 1:   Begin the Equation Writer and type in the first fraction.

(CLEAR) (◄) (EQUATION)

5 (÷) 12 (►) (+)

$$\frac{5}{12}+\square$$

| COMB | PERM | ! | RAND | RDZ | |

Step 2:   Type in the second fraction. Note that when you enter a mixed fraction you must include the + between the integer and fractional parts.

1 (+) 3 (÷) 4

$$\frac{5}{12}+1+\frac{3}{4\square}$$

| COMB | PERM | ! | RAND | RDZ | |

Step 3:   Evaluate the expression. It will display as a decimal.

(EVAL)

1:                    2.16666666667

| COMB | PERM | ! | RAND | RDZ | |

Step 4:   Convert the decimal to a fraction.

(◄) (SYMBOLIC) (NXT)   →Q

1:                          '13/6'

| ↑MAT | ↓MAT | →Q | →Qπ | I | APPLY |

Lesson 9: Arithmetic with Symbols

Arithmetic using symbolic variables is very much like arithmetic using numbers. You can make symbolic calculations on the stack the same way you make numeric calculations—except you use algebraic objects (and tick-mark delimiters) instead of just numbers.

Example: Use symbolic math to create the equation $y = 1 - e^{-ax}$.

Step 1: Enter y and the number 1.

(CLEAR)

$\boxed{\text{'}}$ $\boxed{\alpha}$ $\boxed{\leftarrow}$Y (ENTER) 1 (ENTER)

```
2:                'y'
1:                  1
↑MAT ↓MAT →Q →Qπ  I  APPLY
```
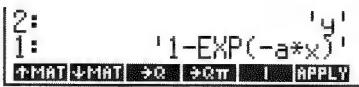
Step 2: Enter the argument $-ax$.

$\boxed{\text{'}}$ $\boxed{-}$ $\boxed{\alpha}$ $\boxed{\leftarrow}$A $\boxed{\times}$ $\boxed{\alpha}$ $\boxed{\leftarrow}$X
(ENTER)

```
3:                'y'
2:                  1
1:             '-a*x'
↑MAT ↓MAT →Q →Qπ  I  APPLY
```

Step 3: Calculate e^{-ax}.

$\boxed{\leftarrow}$ $\boxed{e^x}$

```
3:                'y'
2:                  1
1:          'EXP(-a*x)'
↑MAT ↓MAT →Q →Qπ  I  APPLY
```
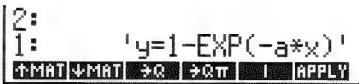
Step 4: Subtract to calculate $1 - e^{-ax}$.

$\boxed{-}$

```
2:                'y'
1:        '1-EXP(-a*x)'
↑MAT ↓MAT →Q →Qπ  I  APPLY
```

Step 5: Form an equation from the two expressions.

$\boxed{\leftarrow}$ $\boxed{=}$

```
2:
1:      'y=1-EXP(-a*x)'
↑MAT ↓MAT →Q →Qπ  I  APPLY
```

Lesson 10: Arithmetic with Complex Numbers

The complex-number capabilities of the HP 48 can affect the results of real-number operations. Certain calculations that would result in an error on most calculators yield valid complex results on the HP 48.

Example: Find the square root of -4.

4 [+/-] [√x]   1:   (0,2)
                                                  ↑MAT ↓MAT →Q →Qπ I APPLY

The answer is a *complex number*—displayed as an ordered pair. The first term is the real component and the second is the imaginary component. This answer is $0 + 2i$ or just $2i$ (the principal square root of -4).

Complex numbers can be expressed in two forms: rectangular $(x + yi)$ and polar ($r(\cos\theta + i\sin\theta)$). The HP 48 can handle both forms, although they are entered as ordered pairs, (x, y) and (r, θ), respectively.

A complex number, like a real number, is a single object. Many functions that work with real numbers also work with complex numbers. You can use complex numbers as arguments for arithmetic operations, and you can use them in symbolic expressions.

Example: Enter the number $3 + 4i$ (rectangular coordinates). Use the [SPC] key to separate the two coordinates.

[⇐][( )] 3 [SPC] 4 [ENTER]   1:   (3,4)
                                                  ↑MAT ↓MAT →Q →Qπ I APPLY

Example: Enter the number with magnitude 5.39 and phase 158.2 degrees (polar coordinates).

Step 1: Set the angle mode to Degrees, then type in the number. (Note that the ∡ character is located above the [SPC] key.)

[➡][MODES] [▼] [α]D OK   1:   (3,4)
[⇐][( )] 5.39 [➡][∡] 158.2   (5.39∡158.2)
                                                  ↑MAT ↓MAT →Q →Qπ I APPLY

Step 2: Enter the polar number on the stack. It's converted to match the current coordinate mode (in this case, Rectangular mode).

(ENTER)

```
2:                    (3,4)
1: (-5.00453860689,
   2.00167263362)
↑MAT↓MAT  →Q  →Qπ  I  APPLY
```

Step 3: Now change the coordinate mode and watch how the complex number changes. (POLAR is located above the (MTH) key.)

[→] POLAR

```
2: (5,∠53.1301023542)
1:      (5.39,∠158.2)
↑MAT↓MAT  →Q  →Qπ  I  APPLY
```

Change the coordinate mode back to Rectangular (press [→] POLAR again) before you go on.

Try some examples to see how easy complex numbers are to use in calculations.

Example: Calculate:
$$\frac{(9+4i)+(-4+3i)}{(3+i)}$$

Step 1: Enter the first two complex numbers.

(CLEAR)
[←]( ) 9 (SPC) 4 (ENTER)
[←]( ) 4 (+/−) (SPC) 3

```
1:                    (9,4)
(-4 3)
↑MAT↓MAT  →Q  →Qπ  I  APPLY
```

Step 2: You do not need to press (ENTER) before pressing (+).

(+)

```
1:                    (5,7)
↑MAT↓MAT  →Q  →Qπ  I  APPLY
```

Step 3: Divide the result by $3 + i$.

[←]( ) 3 (SPC) 1 (÷)

```
1:                (2.2,1.6)
↑MAT↓MAT  →Q  →Qπ  I  APPLY
```

Example: Find the square roots of $8 - 6i$.

Step 1: Type the complex number.

⬅️⬅️🔵( ) 8 (SPC) 6 (+/−)

```
(8 -6)
┌─────┬─────┬───┬───┬──┬──────┐
│↑MAT│↓MAT│→Q│→Qπ│ I │APPLY│
└─────┴─────┴───┴───┴──┴──────┘
```

Step 2: Find the principal square root and make an extra copy.

(√x̄) (ENTER)

```
2:              (3,-1)
1:              (3,-1)
┌─────┬─────┬───┬───┬──┬──────┐
│↑MAT│↓MAT│→Q│→Qπ│ I │APPLY│
└─────┴─────┴───┴───┴──┴──────┘
```

Step 3: Find the conjugate root.

(MTH) (NXT) CMPL (NXT)
CONJ

```
2:              (3,-1)
1:               (3,1)
┌─────┬─────┬─────┬──┬──┬──┐
│SIGN│ NEG │CONJ│  │  │  │
└─────┴─────┴─────┴──┴──┴──┘
```

Algebraics containing complex numbers can be manipulated symbolically in the same way as real-number expressions.

Example: Calculate the sine of $(.6,2)$.

(') (SIN) ⬅️🔵( ) .6 ⬅️🔵( ) 2
(EVAL)

```
1: (2.12429548041,
    2.9933770649)
┌─────┬─────┬─────┬──┬──┬──┐
│SIGN│ NEG │CONJ│  │  │  │
└─────┴─────┴─────┴──┴──┴──┘
```

Example: Use the EquationWriter application to enter an expression representing the complex number $2 - 2i\sqrt{3}$. Then evaluate the expression to get a complex result.

Step 1: Enter the expression.

⬅️🔵(EQUATION)
2 (−) 2 (α)⬅️🔵I (√x̄) 3 (ENTER)

```
1:            '2-2*i*√3'
┌─────┬─────┬─────┬──┬──┬──┐
│SIGN│ NEG │CONJ│  │  │  │
└─────┴─────┴─────┴──┴──┴──┘
```
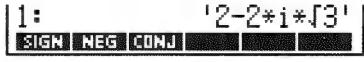
Step 2: Convert the expression to a number.

⬅️🔵(→NUM)

```
1:   (2,-3.46410161514)
┌─────┬─────┬─────┬──┬──┬──┐
│SIGN│ NEG │CONJ│  │  │  │
└─────┴─────┴─────┴──┴──┴──┘
```
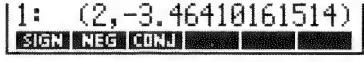
Lesson 11: Arithmetic including Units

You needn't calculate with numbers separated from their natural measurement units if you use the HP 48. A *unit object* is a real number connected to a measurement unit with an underscore character (_). The built-in unit management feature of the HP 48 allows you to attach units to numbers and then do arithmetic with the resulting unit objects. As long as you attach the correct units, it will keep track of the units as you calculate and report the answer in any appropriate measurement you want.

Example: Create the unit object 32_kg*m^2/s^2.

Step 1:   Enter the Units Catalog, key in the value and append the first unit.

(CLEAR) (⮕) (UNITS)
32 MASS   KG

```
1:                           32_kg
KG   G   LB   OZ  SLUG  LBT
```

Step 2:   Append the second unit. This requires that you return to the main Units Catalog screen and select a different category. Note that appending a unit to an object with a unit already attached implies a multiplication of the units.

(⮕) (UNITS)
AREA   M^2

```
1:                        32_kg*m^2
M^2 CM^2  B  YD^2 FT^2 IN^2
```

Step 3:   Append the remaining units in the denominator. Note that pressing the right-shift ((⮕)) before the desired unit implies a *division*—that you want to append the unit in the denominator instead of the numerator of the compound unit.

(⮕) (UNITS)
TIME
(⮕) S   (⮕) S

```
1:                      32_kg*m^2/s^2
YR   D   H   MIN   S   HZ
```

Converting Units

Example: Convert 10_atm (atmospheres) to mmHg (millimeters of mercury).

Step 1: Create the unit object 10_atm.

⟨🔄⟩⟨UNITS⟩
⟨NXT⟩ PRESS 10 ATM

```
1:                    10_atm
PA   ATM   BAR   PSI   TORR   MMH
```

Step 2: Convert to millimeters of mercury. Note that pressing the left-shift (⟨🔄⟩) before the new unit *converts* the previous unit object to the new unit.

⟨🔄⟩ MMH

```
1:                7600_mmHg
PA   ATM   BAR   PSI   TORR   MMH
```

As you perform arithmetic with unit objects, the HP 48 keeps track of the units for you. When different unit objects of the same category are added (or subtracted) the result is automatically converted to the units of the last unit object entered (the level 1 object).

Example: Add up the following lengths and report the answer in centimeters: 41 mm, 19 in, 5 ft, and 12 cm

Step 1: Enter the unit objects onto the stack.

⟨🔄⟩⟨UNITS⟩
LENG 41 MM
19 IN
5 FT
12 CM
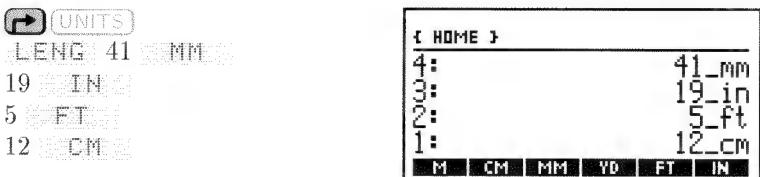
```
{ HOME }
4:                     41_mm
3:                     19_in
2:                      5_ft
1:                     12_cm
 M    CM    MM    YD    FT    IN
```

Step 2: Add up the units. Because the level 1 object has cm as its unit, each addition converts the total to centimeters.

⊕ ⊕ ⊕

```
1:                 216.76_cm
 M    CM    MM    YD    FT    IN
```

One final example illustrates the ability of the HP 48 to factor the unit expression.

Example: Factor N (Newtons) out of 3.5_kg*m^2/s^2.

Step 1:   Enter the unit object.

🠒 (UNITS)
3.5 MASS KG 🠒 (UNITS)
AREA M^2 🠒 (UNITS)
TIME 🠒 S
🠒 S

```
1:          3.5_kg*m^2/s^2
 YR   D   H   MIN   S   HZ
```
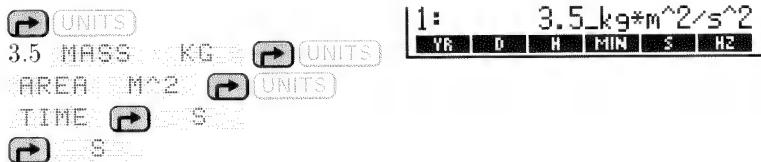
Step 2:   Key in the unit to be factored, using 1 as its value.

🠒 (UNITS) 1 (NXT) FORCE
N

```
2:          3.5_kg*m^2/s^2
1:                     1_N
 N   DYN   GF   KIP   LBF   PDL
```

Step 3:   Perform the unit factoring, using the Units Commands menu
(🠐 (UNITS)).

🠐 (UNITS) UFACT

```
1:               3.5_N*m
CONV UBASE UVAL UFACT →UNIT
```

4

Understanding and Using Memory

Although the Stack can contain many objects, they can all be deleted with one press of the [CLEAR] key. A better place to store information for later use is in User Memory. This chapter explains how memory is organized and how you manage it. Specifically, you'll learn to:

▶ Understand the memory in the HP 48.

▶ Understand variables and directories.

▶ Create variables.

▶ Organize your variables.

▶ Edit and purge variables.

▶ Use variables in calculations.

Lesson 12: Understanding Memory

Thus far it has been convenient to think of the HP 48 as a calculator—albeit an advanced calculator. However, when considering its memory, it is better to think of it as a computer.

The basic unit of storage on a desktop computer is the *named file*. On the HP 48 the basic unit of storage is the named object, or *variable*. Unnamed objects can exist on the stack, but, like computer files, must be named in order to be saved. Envision a variable as a named storage area containing an object.

Variables, reflecting the objects they contain, vary widely in both size and type. Like stored computer files, variables are organized into *directories*—"file folders"—that make it convenient to find them later.

Example: Determine the amount of memory (in bytes) currently
available to store HP 48 variables.

⬅ (MEMORY)   MEM

Variables on the HP 48 are stored in SYSRAM—or on a plug-in card in the case of the expandable HP 48 models. SYSRAM memory is like a desktop computer's Random-Access-Memory (RAM) except that it is *non-volatile*—it isn't erased when the HP 48 is turned off.

The figure below shows how the HP 48 divides up the SYSRAM and the type of variables (in parentheses) stored in each section:

Partitions move depending on current allocation of memory

System (system)	Available Memory	Stack	Program (local)	User (global)	Port 0 (port)

Schematic view of SYSRAM in the HP 48
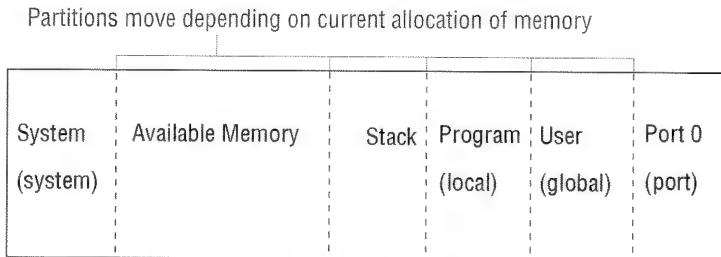
Notice that there are several kinds of variables indicated in the diagram:

- **System variables.** These variables are hidden from you, but are used and updated by the operating system to keep track of everything as you work.

- **Local variables.** These are temporary variables, created by a program, that only exist *during* the execution of that program.

- **Global variables.** These are variables you create (by assigning a name to an object) and can edit, evaluate, and manipulate. They are stored in *user memory*, where they are quickly and immediately accessible. Global variables are hierarchically organized into directories.

- **Port variables.** These are like global variables except that you may not edit them and they cannot be hierarchically organized. They are stored in *port memory*, where they are in "long-term" storage. The HP 48G model only has one port (Port 0), but the HP 48GX model can be configured with as many as 32 additional ports (each containing up to 128 KB of memory).

The remaining lessons in chapter 4 illustrate some of the common things you can do with user memory and global variables. The *HP 48G Series User's Guide* gives you more information about the "boundaries" within SYSRAM and otherwise managing memory (chapter 5) and how to use and access port memory (chapter 28).

Lesson 13: Creating (Naming) Variables

To name an object is to create a global variable. You store an object in user-memory by giving it a name. You can use descriptive names for variables. A name can be as short as one letter—or as long as 127. Global variable names can't be identical to the names of built-in commands and can't begin with a number.

There are two ways to create a new global variable:

■ From the stack, use (STO).
■ From the Variable Browser, use NEW .

The following two examples illustrate each method.

Example: Find the square root of 2 and store the value in a variable named $t1$ (using (STO)).

Step 1: Clear the stack and find the square root of 2.

(CLEAR) 2 (√x)

```
2:
1:          1.41421356237
VECTR MATR LIST HYP REAL BASE
```

Step 2: Enter the name $t1$.

(')(α)(←)T1 (ENTER)

```
2:           1.41421356237
1:                     't1'
VECTR MATR LIST HYP REAL BASE
```

Step 3: Store the object (Level 2) in the name (Level 1). It disappears from the stack.

(STO)

```
1:
VECTR MATR LIST HYP REAL BASE
```

Step 4: Check your current variable menu to confirm that t1 is stored. Notice that the names in the menu are displayed in upper-case for legibility.

(VAR)

```
  T1  EXAM
```

Example: Find the square root of 3 and store the value in a variable named *t2* (using the Variable Browser).

Step 1: Find the square root of 3.

3 $\boxed{\sqrt{x}}$

```
2:
1:              1.73205080757
 T1  EXAM
```

Step 2: Open the Variable Browser and select NEW.

$\boxed{}$ (MEMORY) NEW

```
▒▒▒▒▒▒ NEW VARIABLE ▒▒▒▒▒▒
OBJECT: ██████████████
NAME:
_ DIRECTORY

ENTER NEW OBJECT
 EDIT CHOOS              CANCL  OK
```

Step 3: Retrieve the object in level 1 of the stack ($\sqrt{3}$).

(NXT) CALC OK

```
▒▒▒▒▒▒ NEW VARIABLE ▒▒▒▒▒▒
OBJECT: 1.73205080757
NAME:
_ DIRECTORY

ENTER NEW OBJECT
 RESET CALC TYPES        CANCL  OK
```

Step 4: Enter the name (t2) and press OK. You will see t2 with its contents at the top of the current variable list.

$\boxed{\blacktriangledown}$ $\boxed{\alpha}$ $\boxed{}$ T 2 (ENTER) OK

```
▒▒▒▒▒▒ OBJECTS IN { HOME } ▒▒▒▒▒▒
 t2: 1.73205080757
 t1: 1.41421356237
 EXAMPLES: DIR PRGS ...

 EDIT CHOOS ✔CHK NEW COPY MOVE
```

Step 5: Exit the Variable Browser by pressing (CANCEL).

Lesson 14: Organizing Variables

Whenever a variable is created, it is put into the current *directory*. Directories let you organize variables into meaningful collections. They allow you to work with only with one collection of variables rather than *all* variables at once. Only one directory at a time is active, or *current*. The current directory is shown in the stack display in the line above the stack levels. (At the moment it shows that *HOME* is the current directory.)

Managing and organizing the contents of the current directory is the primary purpose of the Variable Browser.

Example: Review the contents of the current directory.

(→) (MEMORY)
then (▲) and (▼) as needed

```
▒▒▒▒OBJECTS IN { HOME }▒▒▒▒
t2: 1.73205080757
t1: 1.41421356237
EXAMPLES: DIR PRGS ...

EDIT CHOOS ✓CHK NEW COPY MOVE
```

If the particular variable you're seeking is not in the current directory, you can always switch to a different directory and look for it there.

Example: Display the contents of the EXAMPLES directory. This directory and its contents were created by the TEACH command you executed in lesson 1.

Step 1: Display a list of directories.

CHOOS

```
▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
t▒ ┌DIRECTORIES:─────────┐
t1│HOME              │
E)│   EXAMPLES       │
PF│      PRGS        │
I(│      PLOTS      ↓│
  └──────────────────┘
▒▒▒▒▒▒▒▒▒ CANCL  OK
```

Step 2: Select the EXAMPLES directory and switch to it. Notice that the directory line says { HOME EXAMPLES }. This illustrates that EXAMPLES is a subset (or *subdirectory*) of HOME.

▼ OK

```
▒OBJECTS IN { HOME EXAMPLES }▒
 PRGS: DIR MEDIAN « ...
 PLOTS: DIR XSIN « R...
 EQNS: DIR ONE 'SIN(...
 %TILE: « SWAP SORT ...
 PURGEX: « HOME 'EXA...
 EDIT CHOOS ✓CHK NEW COPY MOVE
```

Sometimes a variable may not be stored in the directory where it is most useful. You can move any variable to any directory.

Example: Move the variable *%TILE* to the PRGS subdirectory of EXAMPLES.

Step 1:   Select the variable to be moved, *%TILE*, and press MOVE.

▼ ▼ ▼ MOVE

```
▒▒▒▒▒MOVE VARIABLE(S)▒▒▒▒▒

 NAME:   %TILE
 MOVE TO: ▮

 ENTER VAR NAME OR DIRECTORY PATH
 EDIT CHOOS            CANCL OK
```

Step 2:   Choose the target directory, where you want to put the variable, and press OK. (You can also type in the new path, if you prefer.)

CHOOS ▼ OK
OK

```
▒OBJECTS IN { HOME EXAMPLES }▒
 PRGS: DIR %TILE « S...
 PLOTS: DIR XSIN « R...
 EQNS: DIR ONE 'SIN(...
 PURGEX: « HOME 'EXA...

 EDIT CHOOS ✓CHK NEW COPY MOVE
```

Step 3:   Press (CANCEL) to exit the Variable Browser.

Lesson 15: Editing and Purging Variables

You will often want to modify a variable sometime after you've created it. This, too can be easily accomplished using the Variable Browser.

Example: Store the text string "HP 48SX" under the name TXT. Then change it to "HP 48GX", updating TXT in the process.

Step 1: Open the Variable Browser and select ⬛NEW⬛.

⬛➡⬛ (MEMORY) ⬛NEW⬛

```
▒▒▒▒▒▒▒▒▒▒▒NEW VARIABLE▒▒▒▒▒▒▒▒▒▒▒
OBJECT: ████████████████
NAME:
_DIRECTORY

ENTER NEW OBJECT
 EDIT CHOOS          CANCL OK
```

Step 2: Enter the text string and then the name TXT. Press ⬛OK⬛ to complete the process. (Notice that two different methods for alpha-entry are shown.)

⬛➡⬛ ⬛ ⬛ (α) (α) HP (SPC) 48SX
(ENTER)
(α)-(hold) TXT (release)
(ENTER)
⬛OK⬛

```
▒OBJECTS IN { HOME EXAMPLES }▒
TXT: "HP 48SX"
PRGS: DIR %TILE « S...
▒▒▒▒  ▒▒▒  ▒▒▒▒  ▒ ▒
```

Step 3: Bring the stored object into the editing environment.

⬛EDIT⬛ ⬛EDIT⬛

```
"HP 48SX"

                    CANCL OK
```

Step 4: Move the cursor to the letter "S", then delete it and insert the letter "G."

(▶) (6 times) (DEL) (α)G

```
"HP 48G◆"

                    CANCL OK
```

Step 5: Save the changes and return to the Variable Browser.

(ENTER) ⬛OK⬛

```
▒OBJECTS IN { HOME EXAMPLES }▒
TXT: "HP 48GX"
PRGS: DIR %TILE « S...
▒▒▒▒  ▒▒▒  ▒▒▒▒  ▒ ▒
```

The Variable Browser also allows you to purge variables—several at a time, if you wish—so that unneeded variables don't occupy valuable memory space.

Example: Return to the HOME directory and purge the variables *t1* and *t2*.

Step 1:   Return to the HOME directory.

CHOOS (▲) OK

```
▓▓▓▓ OBJECTS IN { HOME } ▓▓▓▓
 t2: 1.73205080757
 t1: 1.41421356237
 EXAMPLES: DIR TXT "…
▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓
EDIT|CHOOS|✓CHK|NEW | COPY |MOVE
```

Step 2:   Select the variables to be purged by placing a check-mark in front of each of them.

✓CHK (▼) ✓CHK

```
▓▓▓▓ OBJECTS IN { HOME } ▓▓▓▓
✓t2: 1.73205080757
✓t1: 1.41421356237
 EXAMPLES: DIR TXT "…
EDIT|CHOOS|✓CHK|NEW | COPY |MOVE
```

Step 3:   Purge the selected variables from memory.

(NXT) PURG

```
▓▓▓▓ OBJECTS IN { HOME } ▓▓▓▓
 EXAMPLES: DIR TXT "…
RCL | PURG | SIZE |       |CANCL| OK
```

Step 4:   Exit the Variable Browser by pressing (CANCEL).

Lesson 16: Using Variables in Calculations

The variables in the current directory are conveniently available to be used in calculations and expressions. Pressing the (VAR) key brings up a menu of the variables in the current directory. As with all menus, the (NXT) and (PREV) keys allow you move through the variables one "page" at a time—forwards and backwards, respectively.

Example: Store the width and length of a 3-by-5 rectangle in W and L, then use those values to find the area.

Step 1: Enter and store the width and length. (Notice that (STO) can be used to store an object in a variable without using the Variable Browser.) Press (VAR) when you've finished to bring up the menu of variables in the current directory.

(CLEAR)
3 (ENTER) (') (α)L (STO)
5 (ENTER) (') (α)W (STO)
(VAR)

| W | L | EXAM | | | |

Step 2: Recall the two values to the stack using their variable names.

L W

| 2: | 3 |
| 1: | 5 |

| W | L | EXAM | | | |

Step 3: Multiply to find the area.

(×)

| 1: | 15 |

| W | L | EXAM | | | |

5

Solving Equations

This chapter provides a brief introduction to the SOLVE application. The lessons take you through examples of the primary kinds of equation-solving that can be accomplished on the HP 48, including:

- Numerically solving for an unknown variable when all other variables have explicit values.

- Symbolically solving for a variable.

- Finding all roots (real and complex) of a polynomial.

- Solving a system of linear equations.

Lesson 17: Solving for a Variable—Numerically

If you want a numeric solution for an unknown in an equation, you can use the root-finding application (HP Solve). You can solve for a value of any variable without changing the equation—as long as you fill in values for all other variables in the expression or equation.

You can solve an equation or expression over and over—for different known values, and for different combinations of known and unknown variables.
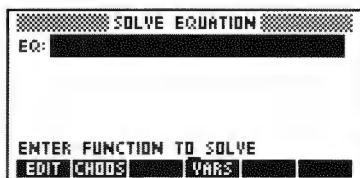
Example: Solve the following expression for x:

$$\frac{6}{x^2 - 9} + \frac{4}{6 + x - x^2} + \frac{2}{x^2 + 5x + 6}$$

This expression was created by the TEACH command earlier and stored as the variable, $RATFUNC$ in the $EQNS$ directory.
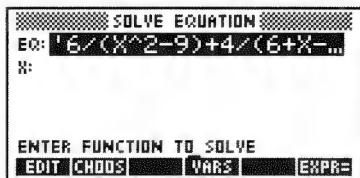
Step 1: Begin the SOLVE application and choose Solve Equation....

⟥ (SOLVE)
OK

```
▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓
EQ: ████████████████████



ENTER FUNCTION TO SOLVE
▐EDIT▐CHOOS▌    ▐VARS▐    ▐    ▌
```

Step 2: The EQ: field is highlighted already, so choose $RATFUNC$ to be the current equation. You will need to switch to the $EQNS$ directory first.

CHOOS
CHOOS ▼ ▼ ▼ ▼   OK
▲   OK

```
▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓
EQ: '6/(X^2-9)+4/(6+X-…
X:


ENTER FUNCTION TO SOLVE
▐EDIT▐CHOOS▌    ▐VARS▐    ▐EXPR=▌
```
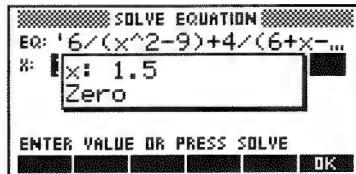
Step 3:   Since *RATFUNC* only has one variable, it must be the unknown variable. Solve for x by highlighting its field and pressing SOLVE.

(▼) SOLVE

```
▓▓▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓▓▓
EQ: '6/(x^2-9)+4/(6+x-...
X: ▐1.5▌
ENTER VALUE OR PRESS SOLVE
▐EDIT▌     ▐VARS▌INFO▌SOLVE▌
```
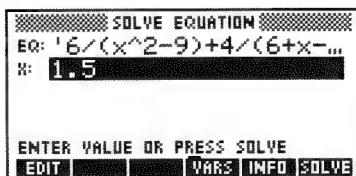
Step 4:   Press INFO to determine the nature of the most recent solution found by the root-finder. The Zero message indicates that the solver found a solution—a point where the expression evaluates to "exactly" (that is, to 12 significant digits) zero.

INFO

```
▓▓▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓▓▓
EQ: '6/(x^2-9)+4/(6+x-...
X: ▐x: 1.5     ▌
   ▐Zero      ▌
ENTER VALUE OR PRESS SOLVE
▐▌ ▐▌ ▐▌ ▐▌ ▐▌ ▐OK▌
```

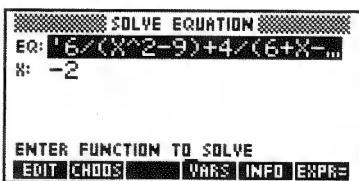*Step 5:*   Press OK to remove the message box.

Searching for Multiple Solutions

Although an equation or expression may have more than one solution, the calculator stops when it finds one. Because there was no value listed for x before you chose to solve for x, the solver began looking for an answer at $x = 0$ and reported the first solution it found. However, you can tell the solver to begin its search from a different point by entering an *estimate* of the solution before solving for a variable.

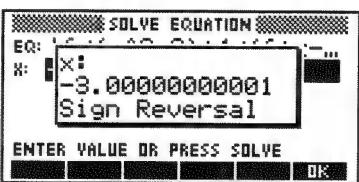Example: Re-solve *RATFUNC* beginning with a guess of $x = -2$.

Step 1: You're already working with *RATFUNC*, and the x variable field is highlighted, so you are ready to enter the guess.

2 (+/-) (ENTER)

```
▓▓▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓▓▓
EQ: ▊6/(X^2-9)+4/(6+X-▊
X: -2


ENTER FUNCTION TO SOLVE
▐EDIT▐CHOOS▐    ▐VARS▐INFO▐EXPR=
```

Step 2: Solve for x again and examine the new solution.

(▼) SOLVE INFO

```
▓▓▓▓▓▓▓▓ SOLVE EQUATION ▓▓▓▓▓▓▓▓
EQ: ▊  ▗▄▄▄▄▄▄▄▄▄▄▄▄▄▄▄▄▄▖  ▊-▊
X: ▊ │X:                │▊
     │-3.00000000001   │
     │Sign Reversal    │
     ▝▀▀▀▀▀▀▀▀▀▀▀▀▀▀▀▀▀▘
ENTER VALUE OR PRESS SOLVE
▐    ▐    ▐    ▐    ▐    ▐  OK
```

*Step 3:* Press OK to remove the message box.

Interpreting the Results

The Sign Reversal message means that the solver has found two adjacent sample points at which the value of the expression is opposite in sign, but hasn't found one sample point that makes the expression zero (to 12 digits). This can happen at a legitimate solution—the finite numerical precision making it impossible for the HP 48 to find the actual zero. But it can also occur at a discontinuity, where the graph of the equation "jumps" across the x-axis without ever touching it.

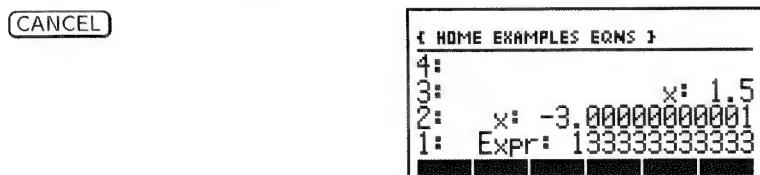### Two kinds of Sign Reversals
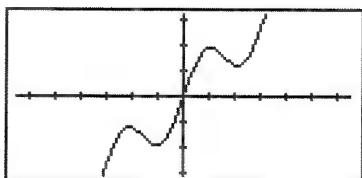
Actual Root
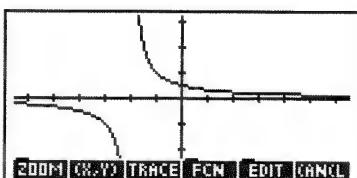
Discontinuity

To decide which case it is, you should find the value of the expression at the Sign Reversal point.

Example: Find the value of the expression at the computed value of
            x in order to decide whether it is a solution to $RATFUNC$
            or represents the location of a discontinuity.

Step 1:   Press ⬆ to move the highlight to the EQ: field and press
           EXPR=. The value of the expression at the computed value
           of x is returned to the stack.

Step 2:   Return to the stack to view the value of the expression
           (labeled Expr:).

[CANCEL]

```
{ HOME EXAMPLES EQNS }
4:
3:                          x: 1.5
2:        x: -3.000000000001
1:     Expr: 133333333333
```

Because the value of the expression is not close to zero, in all
likelihood, there is a discontinuity at $x = -3$. (You can confirm
this by substituting -3 into the original equation and observing
that it generates denominators equal to zero—a sign of a potential
discontinuity.)

In general, whenever you expect multiple solutions, you'll probably
save yourself some time and effort by plotting the expression and using
the graphical analysis tools instead of the SOLVE application (see
lesson 26 for an example).

Press ➡ [SOLVE]   OK   to return to the SOLVE application and try
solving another equation—this time keying it in yourself.

Example: Find the measure (in degrees) of the largest angle in a
            triangle with sides of 4, 7, and 9, with θ as the largest
            angle and c as the largest side). Use the Law of Cosines:

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$

Step 1: Move the highlight to the EQ: field (if necessary) and enter the equation. (θ can be typed using [α][←]F or selecting it from CHARS.)

['] [α][←]C [y^x] 2 [←]◻
[α][←]A [y^x] 2 [+] [α][←]B
[y^x] 2 [−] 2 [×] [α][←]A [×]
[α][←]B [×] [COS] [α][←]F
[ENTER]

```
░░░░░░░░░ SOLVE EQUATION ░░░░░░░░░
EQ: 'c^2=a^2+b^2-2*a*b...
C: ███████████    A:
B:                θ:

ENTER VALUE OR PRESS SOLVE
[EDIT][    ][    ][VARS][    ][SOLVE]
```

Step 2: Store the known values.

9 [ENTER]
4 [ENTER]
7 [ENTER]

```
░░░░░░░░░ SOLVE EQUATION ░░░░░░░░░
EQ: 'c^2=a^2+b^2-2*a*b...
C: 9             A: 4
B: 7             θ: ███████████

ENTER VALUE OR PRESS SOLVE
[EDIT][    ][    ][VARS][    ][SOLVE]
```

Step 3: Solve for the angle (θ).

SOLVE

```
░░░░░░░░░ SOLVE EQUATION ░░░░░░░░░
EQ: 'c^2=a^2+b^2-2*a*b...
C: 9             A: 4
B: 7             θ: 106.601...

ENTER VALUE OR PRESS SOLVE
[EDIT][    ][    ][VARS][INFO][SOLVE]
```

Step 4: How long would side c be if the obtuse angle, θ, was 120 degrees? Enter 120 into θ and solve for c.

120 [ENTER]
[▼] SOLVE

```
░░░░░░░░░ SOLVE EQUATION ░░░░░░░░░
EQ: 'c^2=a^2+b^2-2*a*b...
C: 9.64365...    A: 4
B: 7             θ: 120

ENTER VALUE OR PRESS SOLVE
[EDIT][    ][    ][VARS][INFO][SOLVE]
```

Step 5: Exit the SOLVE application. Notice that the labeled results of each execution of SOLVE are put on the stack for you.
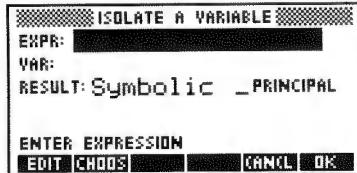
Lesson 18: Solving for a Variable—
Symbolically

The HP 48 also allows you to isolate a variable symbolically—that is, rearrange an expression so that the desired variable is isolated on one side of the equal sign. Once a variable is isolated, it is easy to save the rearranged expression as its definition.
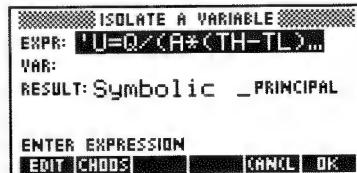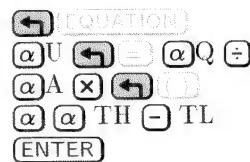
Example: Solve for T_H in the following heat transfer equation, then create variable TH containing the resulting equation:

$$U = \frac{q}{A\,(T_H - T_L)}$$

Step 1:   Open the SYMBOLIC application and select Isolate var....

[🠪] (SYMBOLIC)
(▼) (▼) (▼)
  OK

```
▓▓▓▓▓ISOLATE A VARIABLE▓▓▓▓▓
EXPR: ███████████████████████
VAR:
RESULT: Symbolic   _PRINCIPAL

ENTER EXPRESSION
EDIT CHOOS        CANCL OK
```

Step 2:   Create and enter the equation.

[⬅] (EQUATION)
(α)U [⬅] (=) (α)Q (÷)
(α)A (×) [⬅] ( )
(α) (α) TH (−) TL
(ENTER)

```
▓▓▓▓▓ISOLATE A VARIABLE▓▓▓▓▓
EXPR: 'U=Q/(A*(TH-TL)...
VAR:
RESULT: Symbolic   _PRINCIPAL

ENTER EXPRESSION
EDIT CHOOS        CANCL OK
```

Step 3:   Specify the variable of solution and solve for it.

(▼) (α)T (α)H (ENTER)
  OK

```
1:              'TH=Q/U/A+TL'
VECTR MATR LIST HYP REAL BASE
```

Step 4:   Define a new variable, *TH*, from this equation. ⬅️ (DEF) stores the expression to the right of the equal sign ('Q⁄U⁄A+TL') in the variable name to the left of the equal sign. Press (VAR) afterwards to view the new entry in the menu.

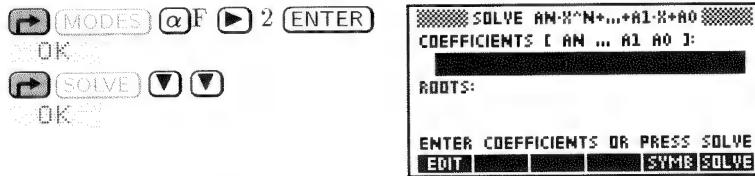⬅️ (DEF) (VAR) | TH | θ | B | A | C | X |
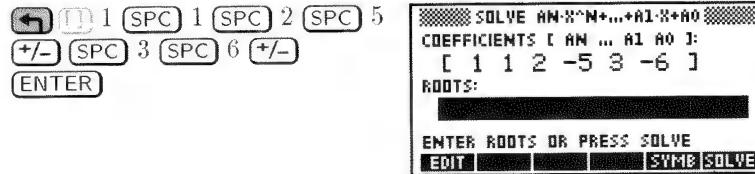
Lesson 19: Finding all Roots of a Polynomial

A polynomial has the same number of roots as its degree—although not all of these roots will be real or unique. The HP 48 offers an easy way to numerically calculate all roots—*both real and complex*—of a polynomial. The coefficients of the polynomial may be either real or complex.

Example: Find all roots of $x^5 + x^4 + 2x^3 - 5x^2 + 3x - 6$.

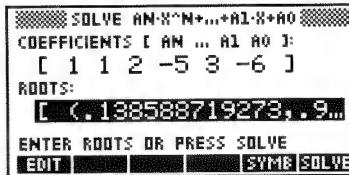*Step 1:* Fix the display to two decimal places and then choose the Solve poly... from the SOLVE choose list.

🢅 (MODES) (α)F (▶) 2 (ENTER)
  OK
🢅 (SOLVE) (▼) (▼)
  OK

```
▓▓▓▓ SOLVE AN·X^N+...+A1·X+A0 ▓▓▓▓
COEFFICIENTS [ AN ... A1 A0 ]:
▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮
ROOTS:

ENTER COEFFICIENTS OR PRESS SOLVE
 EDIT ▮     ▮     ▮  SYMB SOLVE
```

Step 2: Enter the coefficients of the polynomial, beginning with the coefficient of the highest degree. Press (SPC) between each coefficient.

🢅 (⊞) 1 (SPC) 1 (SPC) 2 (SPC) 5
(+/−) (SPC) 3 (SPC) 6 (+/−)
(ENTER)

```
▓▓▓▓ SOLVE AN·X^N+...+A1·X+A0 ▓▓▓▓
COEFFICIENTS [ AN ... A1 A0 ]:
 [ 1 1 2 -5 3 -6 ]
ROOTS:
▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮
ENTER ROOTS OR PRESS SOLVE
 EDIT ▮     ▮     ▮  SYMB SOLVE
```

Step 3: Solve the polynomial.

SOLVE

```
▓▓▓▓ SOLVE AN·X^N+...+A1·X+A0 ▓▓▓▓
COEFFICIENTS [ AN ... A1 A0 ]:
 [ 1 1 2 -5 3 -6 ]
ROOTS:
▓[ (.138588719273,.9▓
ENTER ROOTS OR PRESS SOLVE
 EDIT ▮     ▮     ▮  SYMB SOLVE
```

Step 4:   Exit the SOLVE application and view the results on the
            Stack.

(NXT)   OK   or (CANCEL)

```
1: Roots:
    [ (0.14,1.00) (0.1…
 TH   A   B   A   C   X
```

Lesson 20: Solving a System of Linear Equations

The HP 48 can solve a system of linear equations. To create your system of equations, you can either choose them from among those you've stored, or enter them directly.

As you solve a system of equations, remember that a system of equations can be represented by a single matrix equation of the form $\mathbf{A} \cdot \mathbf{X} = \mathbf{B}$:

Equation Form   **Matrix Form**

$$
\begin{array}{rcr}
3x + y + 2z &=& 13 \\
x + y - 8z &=& -1 \\
-x + 2y + 5z &=& 13
\end{array}
\quad \longrightarrow \quad
\begin{bmatrix} 3 & 1 & 2 \\ 1 & 1 & -8 \\ -1 & 2 & 5 \end{bmatrix}
\begin{bmatrix} x \\ y \\ z \end{bmatrix} =
\begin{bmatrix} 13 \\ -1 \\ 13 \end{bmatrix}
$$

The HP 48 makes use of this representation to solve systems of linear equations rapidly and efficiently.

Example: Solve the system of linear equations shown above. (This example assumes that the current display mode is Std.)

Step 1:   Select `Solve lin sys...` from the SOLVE menu.

Step 2:   Enter the matrix of coefficients (Matrix A) using the MatrixWriter.

Step 3: Enter the vector of constants (B) and solve the system.

▼ ⬅ ▯ 13 (SPC) 1 (+/−) (SPC)
13 (ENTER)
SOLVE

```
▨▨▨▨▨SOLVE SYSTEM A·X=B▨▨▨▨▨
A: [[ 3  1  2 ]   [  1  1 …
B: [ 13 -1  13 ]
X: [  2  5  1 ]

ENTER SOLUTIONS OR PRESS SOLVE
▮EDIT▮CHOOS▮    ▮    ▮    ▮SOLVE
```

Step 4: Exit the SOLVE application and view the results on the stack.

(CANCEL)

```
1: Solutions:
    [ 2  5  1 ]
▮    ▮    ▮    ▮    ▮    ▮
```

6

Plotting Equations and Analyzing Graphs

This chapter provides a brief introduction to the PLOT application. The lessons take you through examples of:

▶ Plotting a simple function.

▶ Modifying how a plot is displayed.

▶ Plotting several functions at once.

▶ Plotting functions of two variables in three dimensions.

▶ Using various plot types.

▶ Finding the roots of a function graphically.

▶ Finding the slope of a function at a point.

▶ Finding the line tangent to a function at a point.

▶ Finding a local maximum.

▶ Finding and shading the area under a curve.

Lesson 21: Plotting a Function

A *function* takes one or more arguments as inputs and transforms them mathematically into exactly one output. A function can be plotted by graphing a series of outputs against a corresponding series of inputs.
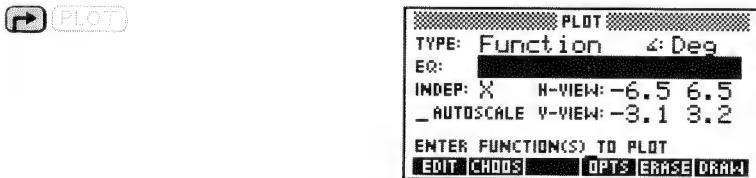
Plotting functions on the HP 48 is a matter of doing the following:

▸ Entering or choosing the function to plot.

▸ Declaring the independent variable and the horizontal range of that you want to view.

▸ Either declaring the vertical range to be displayed or choosing to let the HP 48 automatically scale it for you.

▸ Making sure that the angle mode (Degrees, Radians, Grads) is properly set.

▸ Setting the other plot display options.

All of these steps can be accomplished smoothly and quickly in the PLOT application.

Example: Plot $f(x) = \sin x$.

Step 1:   Open the PLOT application. You may or may not already have a function entered in EQ:.

     ⟦→⟧ ⟦PLOT⟧

                       ░░░░░░░░░░PLOT░░░░░░░░░░
                       TYPE: Function   ∡ Deg
                       EQ: ▮
                       INDEP: X   H-VIEW: −6.5 6.5
                       _AUTOSCALE V-VIEW: −3.1 3.2
                       ENTER FUNCTION(S) TO PLOT
                       ▐EDIT▐CHOOS▐ ▐OPTS▐ERASE▐DRAW▐

Step 2:   Enter the function into the EQ: field.

     ⟦'⟧ ⟦SIN⟧ ⟦α⟧X ⟦ENTER⟧

                       ░░░░░░░░░░PLOT░░░░░░░░░░
   TYPE: Function   ∡ Deg
                       EQ: 'SIN(X)'
                       INDEP: ▮   H-VIEW: −6.5 6.5
                       _AUTOSCALE V-VIEW: −3.1 3.2
                       ENTER INDEPENDENT VAR NAME
                       ▐EDIT▐ ▐ ▐OPTS▐ERASE▐DRAW▐

Step 3: The independent variable, X, and its default range
(in H-VIEW) need no changing. To let the calculator
automatically scale the vertical axis for you, make sure that
there is a check-mark in the AUTO: field.

▼ ◀ ✓CHK

```
▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒PLOT▒▒▒▒▒▒▒▒▒▒▒▒▒
TYPE: Function      ∠: Deg
EQ:   'SIN(X)'
INDEP: X   H-VIEW: -6.5 6.5
✓AUTOSCALE V-VIEW: Auto

AUTOSCALE VERTICAL PLOT RANGE?
░░░░░░░░░░░░░░░░ ✓CHK OPTS ERASE DRAW
```

Step 4: Change the angle mode from Degrees to Radians.

▼ ▶
CHOOS ▼ (ENTER)

```
▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒PLOT▒▒▒▒▒▒▒▒▒▒▒▒▒
TYPE: Function      ∠: Rad
EQ:   'SIN(X)'
INDEP: X   H-VIEW: -6.5 6.5
✓AUTOSCALE V-VIEW: Auto

CHOOSE ANGLE MEASURE
░░░░░░ CHOOS ░░░░░░ OPTS ERASE DRAW
```

Step 5: Erase any previous plots and draw the new one.

ERASE DRAW
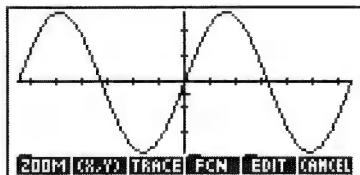
Return to the PLOT application by pressing (CANCEL).

Lesson 22: Modifying the Display of a Plot

There are several display options that are set on the PLOT OPTIONS screen. The default settings are shown in the figures below.

```
▓▓▓▓▓▓▓▓PLOT OPTIONS▓▓▓▓▓▓▓▓
INDEP: ▓X▓  LO: Dflt   HI: Dflt
✓AXES      ✓CONNECT  _SIMULT
STEP: Dflt  _PIXELS
H-TICK: 10  V-TICK: 10    ✓PIXELS

ENTER INDEPENDENT VAR NAME
▀EDIT▀▀▀▀▀▀▀▀▀▀▀▀▀▀▀CANCL▀OK▀
```
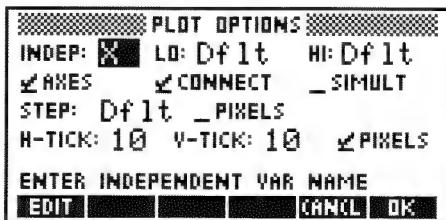
The Plot Options Screen

The options available on this allow you to:

▶ Set a *plotting domain* (LO to HI) that is different from the *displayed* horizontal view. This is particularly useful with POLAR plots.

▶ Choose to display the plotted function with (✓CONNECT) or without (_CONNECT) connecting lines between sample points.

▶ Choose to display the plots of multiple functions either simultaneously (✓SIMULT) or sequentially (_SIMULT).

▶ Choose to display the plotted function(s) with (✓AXES) or without (_AXES) the coordinate axes.

▶ Choose the step-size (STEP)between points sampled during plotting in either pixels/tick-mark (✓PIXELS) or coordinate units (_PIXELS).

▶ Choose your own spacing for the tick-marks on the axes (H-TICK and V-TICK) in either pixels (✓PIXELS) or coordinate units (_PIXELS).

To return to the main plot screen after changing some options, press OK (or (ENTER)). Press CANCL (or (CANCEL)) if you don't want to save the changes.

Lesson 23: Plotting Several Functions

To plot several functions on the same display, you must enter a *list* of functions in the EQ field of the Plot screen. The easiest approach is to create and name each function and then use the Variable Browser to select which group to plot. The following example uses functions that were created and named for you by the TEACH command when you executed it in Lesson 1.

Example: Gather the following functions into a list and store the list in the EQ: field: *ONE*, *TWO*, *THREE*, and *FOUR*.

Step 1: In the main Plot screen, move the highlight to the EQ: field and open the Variable Browser. Note when you access the Variable Browser from within PLOT, it only displays objects in the current directory that can be plotted. Move to the EQNS directory, if necessary, and use the arrow keys to highlight the *ONE* equation.

(arrow keys) CHOOS
CHOOS, select EQNS, OK
(▲) or (▼) (if necessary)
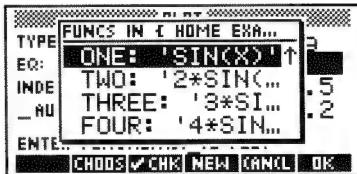
Step 2: Select the desired functions by putting check-marks in front of the names.

✓CHK
(▼) ✓CHK
(▼) ✓CHK
(▼) ✓CHK
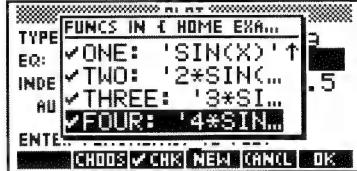
Step 3:   Enter the list of checked functions into the EQ: field and set a vertical display range of -4 to 4 (large enough to display the "largest" function in the list). You must turn off the AUTOSCALE feature if it is currently checked before you can see your V-VIEW. Because it uses only the first function in the list to determine the vertical scale, autoscaling while plotting a list of functions can give inconvenient and surprising results and is generally not recommended.

OK
▼ ▼
◀ ✓CHK ▶ , if necessary
4 +/– ENTER 4 ENTER

```
▓▓▓▓▓▓▓▓▓▓▓▓▓▓ PLOT ▓▓▓▓▓▓▓▓▓▓▓▓▓▓
TYPE: Function    ∢ Rad
EQ:  { 'SIN(X)'  '2*SI...
INDEP: X     H-VIEW: –6.5  6.5
_ AUTOSCALE V-VIEW: –4     4
CHOOSE TYPE OF PLOT
███████ CHOOS ████████ OPTS ERASE DRAW
```

Example: Plot the list of functions you just selected. Plot them simultaneously.

Step 1:   Set the Simultaneous plot option.

OPTS
▼ ▶ ✓CHK

```
▓▓▓▓▓▓▓▓▓ PLOT OPTIONS ▓▓▓▓▓▓▓▓▓
INDEP: X   LO: –6.5   HI: 6.5
✓AXES   ✓CONNECT   ▓SIMULT
STEP: Dflt   _ PIXELS
H-TICK: 10   V-TICK: 10   ✓PIXELS
PLOT FUNCTIONS SIMULTANEOUSLY?
█████████ ✓CHK ██████ CANCL OK
```

Step 2:   Erase the PICTURE display and draw the plot.

OK   ERASE   DRAW
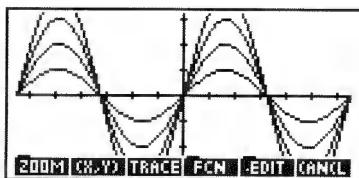
Return to the main PLOT screen by pressing CANCEL when you've finished viewing the plot.

You may plot as many functions simultaneously as memory allows—as long as they are all gathered together in a list. You may either build this list from a group of already-created variables (as in the previous example) or enter the list from scratch using the command line.

Lesson 24: Plotting Functions in Three Dimensions

There are six different plot types that can be used to help you visualize functions of two variables. Some of these only plot the given function within a region in 3-dimensional space, called the *View Volume*, defined by ranges on each of the three coordinate axes.
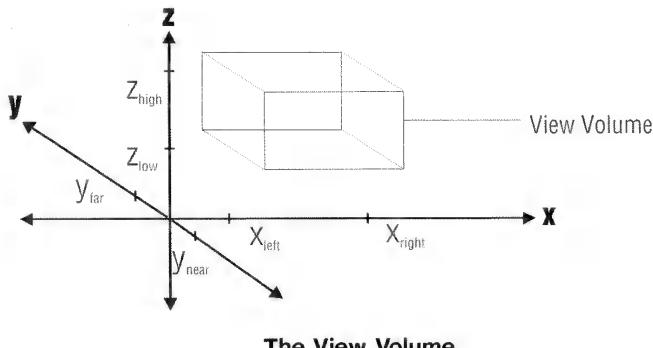
The View Volume

The other important parameter for three-dimensional plotting is the *eyepoint*, the point in space from which you are viewing the View Volume. The eyepoint determines the way that the View Volume is projected onto the two-dimensional plotting display.
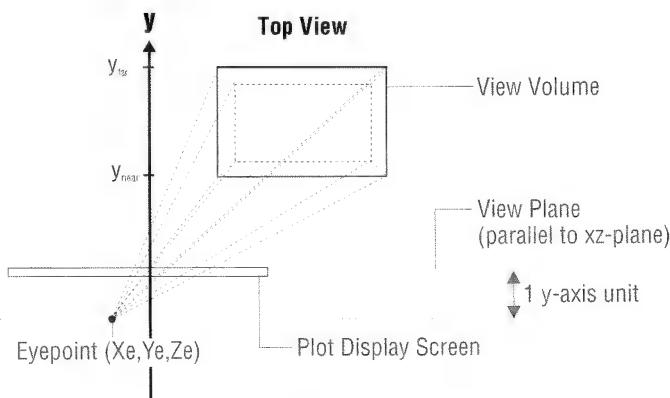
The Relationship of the Eyepoint, View Volume, and Plot Display

Note that the three-dimensional coordinate system on the HP 48 is somewhat constrained compared to its abstract, mathematical counterpart. Specifically:

- The plot display screen does not rotate in space; it always stays parallel to the xz-plane and perpendicular to the y-axis. This means that, visually, "height" is always along the z-axis, "width" along the x-axis, and "depth" along the y-axis.
- The y-axis is always oriented so that negative y-values are "nearer" and positive y-values "farther" away from the plot display.
- The eyepoint must be at least one unit "nearer" than y_{near} ($y_e \leq y_{near} - 1$) and can never exist "within" the View Volume. Whenever you move the eyepoint, you also move the plot display screen so that it remains exactly one unit away in the direction of the y-axis.
- You cannot plot a "top" view of a function (looking down onto the xy-plane) simply by moving the eyepoint. (You may simulate this by transforming coordinates, however.)

Example: Plot a wireframe view of: $f(X, Y) = X^3 Y - XY^3$

Step 1:   Change the plot type to Wireframe and enter the function.

▲ @W ▼
⊣ @X (yˣ) 3 ✕ @Y ⊟ @X
✕ @Y (yˣ) 3 (ENTER)

```
░░░░░░░░░░ PLOT ░░░░░░░░░░
TYPE: Wireframe  ∡:Rad
EQ:   'X^3*Y-X*Y^3'
INDEP: X         STEPS: 10
DEPND: Y         STEPS: 8

ENTER INDEPENDENT VAR NAME
 EDIT              OPTS ERASE DRAW
```

Step 2:   Set the number of horizontal and vertical steps (or "frames") to plot.

▶ 12 (ENTER) ▶ 12 (ENTER)

```
░░░░░░░░░░ PLOT ░░░░░░░░░░
TYPE: Wireframe  ∡:Rad
EQ:   'X^3*Y-X*Y^3'
INDEP: X         STEPS: 12
DEPND: Y         STEPS: 12

CHOOSE TYPE OF PLOT
      CHOOS        OPTS ERASE DRAW
```
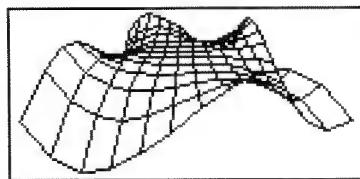
Step 3:   Set the size of the View Volume and location of the eyepoint.

OPTS 1 (+/−) (ENTER) 1
(ENTER) 1 (+/−) (ENTER) 1
(ENTER) .4 (+/−) (ENTER) .4
(ENTER) 0 (ENTER) 2 (+/−)
(ENTER) 1 (ENTER)

```
░░░░░░░░▒PLOT OPTIONS▒░░░░░░░░
X-LEFT: ▓-1▓    X-RIGHT: 1
Y-NEAR: -1      Y-FAR:  1
Z-LOW: -.4      Z-HIGH: .4
XE: 0      YE: -2    ZE: 1
ENTER MINIMUM X VIEW-VOLUME VAL
▐EDIT▌          ▐CANCL▌▐OK▌
```
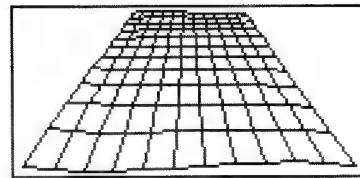
Step 4:   Save the settings, erase the previous plot, and draw the new one.

OK ERASE DRAW
Then (←)(PICTURE) after plotting

Step 5:   Return to the plot input form and change the *z*-coordinate of the eyepoint to 20 to see what the function looks like from a "high" vantage point. (Remember that you are still looking forwards as well as downwards at the function.)

(CANCEL)
OPTS (◄) 20 (ENTER) OK
ERASE DRAW
Then (←)(PICTURE) after plotting

Step 6:   Return to the plot input form and change the *z*-coordinate of the eyepoint to zero and the *x*-coordinate to -8 and redraw the plot. This view shows the effect of changing the horizontal component.

(CANCEL)
OPTS (▲) 8 (+/−) (ENTER) (►)
0 (ENTER) OK
ERASE DRAW
Then (←)(PICTURE) after plotting
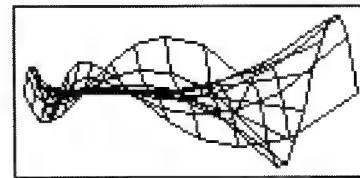
Lesson 25: Introducing the Plot Types

There are fifteen different kinds of plots that the HP 48 can draw. Each of them is discussed in detail in the *HP 48G Series User's Guide*, but the table below gives you a brief introduction to each.
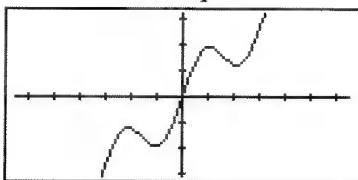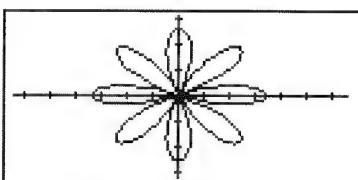
HP 48 Plot Types

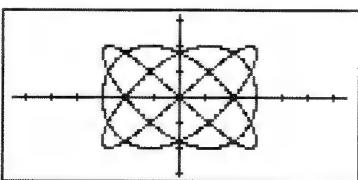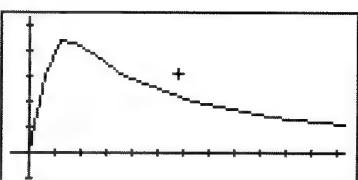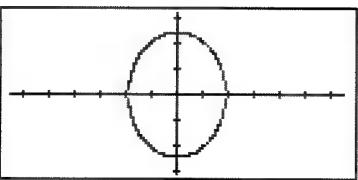| Plot Type and Description	Example
Function Plots true functions of a single variable (y as a function of x) on an xy-coordinate system. (Shown: $y = x + \sin 2x$)	
Polar Plots polar functions of a single variable (r as a function of θ) on an xy-coordinate system. (Shown: $r = 2 \cos 4\theta$)	
Parametric Plots the curve determined by two parametric functions, $x(t)$ and $y(t)$, that are combined a complex-valued function, $f(t) = x(t) + \mathbf{i}y(t)$. (Shown: $f(t) = 3 \sin 3t + \mathbf{i}2 \sin 4t$)	
Differential Equation Plots a phase plane of a first-order differential equation at given initial conditions. (Shown: yt-phase of $y'(t) = \frac{1}{1+t^2} - 2y^2$)	
Conic Plots both solutions to the quadratic equation representing a conic section. (Shown: $f(x, y) = 5x^2 + 3^2 - 18$)	

Plot Type and Description   **Example**

Truth

Plots truth-valued functions, such
as inequalities, by testing each
point in the range to determine if
the function is true or false and
that point. (Shown:
$(x^2 + y^3)\mathbf{mod}4 < 2$)

Histogram

Plots the data in a designated
column of the current statistical
matrix after it has been sorted
into numerical ranges (or *bins*).
A Histogram is a Bar plot where
each bar represents the number of
data points that fall into a
particular bin.

Bar

Plots the value of each data point
in a designated column of the
current statistics matrix as a
vertical bar.

Scatter

Plots the data in one column of
the current statistics matrix
versus the data in a second
column.

Slopefield

For a function, $F(x, y) = z$, plots
a lattice of line segments whose
slopes represent the function
value (z) at their centerpoint,
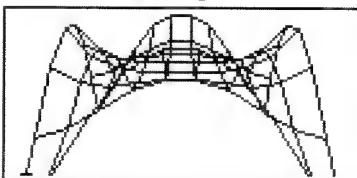(x, y). (Shown: $F = \sin xy$)

| Plot Type and Description	Example

Wireframe

Plots a perspective, wireframe view of the surface determined by a function of two variables. (Shown: $F = x^4 - 4x^2y^2 + y^4$)

Pseudo-Contour

For a function, $F(x, y)$, plots a lattice of line segments that are each tangent to a contour of the function (a curve satisfying $F(x, y)$=constant). This allows your eye to pick out the contours without actually plotting them. (Shown: $F = (x^2 - 1)/(y^2 - 1)$)
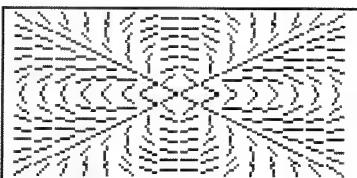
Y-Slice

Plots a series of cross-sections of the surface determined by the current function of two variables and can create an animation of them to help you visualize a moving slice through the surface. (Shown: $F = x^4 - 4x^2y^2 + y^4$)
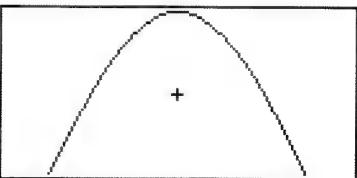
Gridmap

Plots a rectilinear grid as it is "distorted" under the mapping of a complex-valued function $(F(x + \mathbf{i}y))$. (Shown: $F = \sin(x + \mathbf{i}y)$)
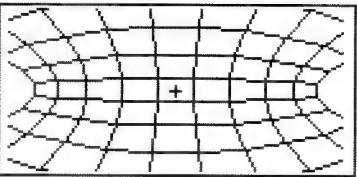
Parametric-Surface

Plots a perspective, wireframe model of a parametrized surface $(F(u, v) = x(u, v)\mathbf{i} + y(u, v)\mathbf{j} + z(u, v)\mathbf{k}$). (Shown: $x(u, v) = \sin 3x + \frac{1}{2}y$; $y(u, v) = \frac{1}{2}y$; $z(u, v) = \cos 3x$.)
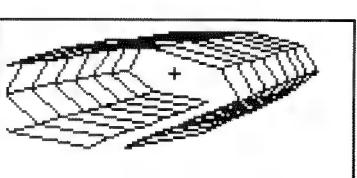
Lesson 26: Finding Roots Graphically

In Lesson 17, you found all of the roots of a polynomial using the
SOLVE application. This lesson shows you how to use the special
analytic tools in the PICTURE environment to find the roots of a
function *visually* as well as search for other information about a
function.

Example: Plot the function, $X^5 + X^4 - 5X^3 - 2X^2 + X - 4$, and
find its real roots.

Step 1: Begin the PLOT application and reset the plot display
options.
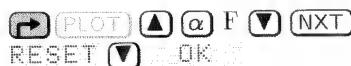
⟮⬏⟯⟮PLOT⟯⟮▲⟯⟮α⟯ F ⟮▼⟯ ⟮NXT⟯
RESET ⟮▼⟯ OK
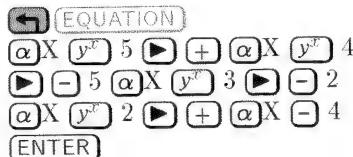
Step 2: Enter the function.

⟮⬑⟯⟮EQUATION⟯
⟮α⟯X ⟮yˣ⟯ 5 ⟮▶⟯ ⟮+⟯ ⟮α⟯X ⟮yˣ⟯ 4
⟮▶⟯ ⟮−⟯ 5 ⟮α⟯X ⟮yˣ⟯ 3 ⟮▶⟯ ⟮−⟯ 2
⟮α⟯X ⟮yˣ⟯ 2 ⟮▶⟯ ⟮+⟯ ⟮α⟯X ⟮−⟯ 4
⟮ENTER⟯

Step 3: Erase the "blackboard" (the PICTURE display) and draw
the function.

ERASE
DRAW
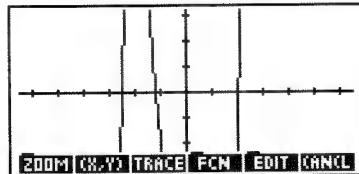
Step 4: You can see that there are three real roots (where the plot crosses the x-axis, but you cannot see the whole function very well. Zoom the vertical scale out to display the plot better. (Vertical Zoom Out is one of 15 different kinds of zoom available to you).

ZOOM (NXT) VZOUT
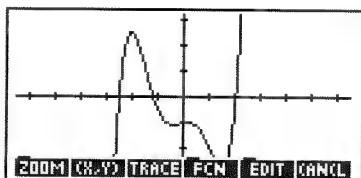
Step 5: Find a root. Once the HP 48 finds a root, the cursor will be positioned as close to the root as possible, the calculated value will be shown on the display and a tagged copy of the root placed on the Stack.

FCN ROOT

ROOT: -1.18814632914
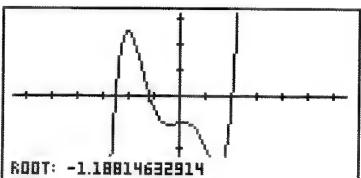
Step 6: Find a different root. Move the cursor over towards the left-most root.

(◄) as needed
(NXT) (to redisplay the menu)
ROOT

ROOT: -2.5104297636
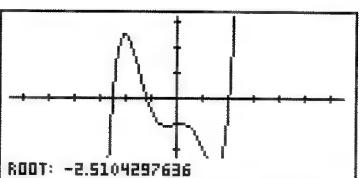
Step 7: Find the third root.

(►) as needed
(NXT) (to redisplay the menu)
ROOT

ROOT: 2.04160529092
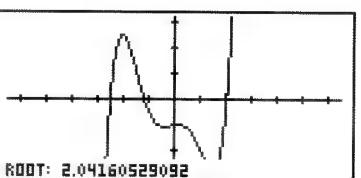
Lesson 27: Finding Slope, Tangents, and Critical Points

The following examples show you other kinds of analysis you can perform on the currently plotted function.

Example: Using the same polynomial you just plotted in the previous lesson ($X^5 + X^4 - 5X^3 - 2X^2 + X - 4$), find the slope at $x = -0.4$ and draw a tangent line to the function at $x = 0.3$.

Step 1:   Turn on TRACE mode and move the cursor using the ◄ and ► keys.

NXT (to redisplay the menu)
NXT PICT TRACE
◄ and ► as needed
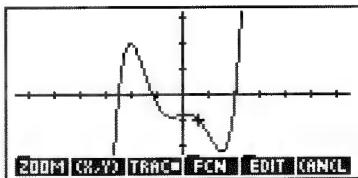
Step 2:   Display the cursor coordinates and move the cursor over until the x-coordinate equals -0.4.

(X,Y)
► or ◄ as needed
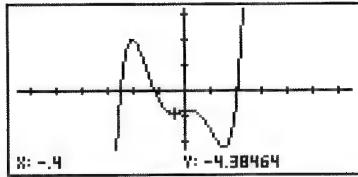
Step 3:   Find the slope.

NXT (to redisplay the menu)
FCN SLOPE
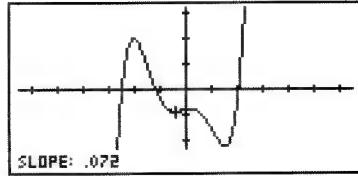
Step 4: Move the cursor to $x = 0.3$, and draw the line tangent to the function at that point.

▶ (7 times)
(NXT) (to redisplay the menu)
(NXT) TANL

```
┌─────────────────────────────────┐
│                    │            ││
│                    │  ╱╲        ││
│ ──────────         │ ╱  ╲       ││
│           ───────  │╱    ╲      ││
│──────────────────┼─────────╲────│─
│                  │───────    ╲  ││
│                  │       ───────╲│
│                  │            │ ╲│
│ TANLINE: 'Y=-1.4015*X-3.58402'  │
└─────────────────────────────────┘
```
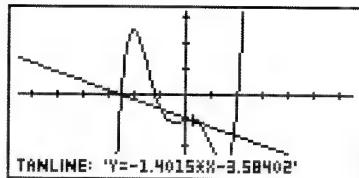
Example: Determine the point where the current function has a local maximum in the region near the y-axis.

Step 1: Magnify the display to show the target region more clearly. Move the cursor to one corner of the target region and use Box Zoom.

▲ (3 times) ◀ (6 times)
(NXT) (to redisplay the menu)
PICT ZOOM BOXZ
▼ (5 times) ▶ (12 times)

```
┌─────────────────────────────────┐
│                    │            ││
│                    │  ╱╲        ││
│ ──────────         │ ╱  ╲       ││
│           ───────  │╱    ╲      ││
│──────────────────┼──────┌──╲────│─
│                  │──────│──────  │
│                  │      └────    │
│                  │            │  │
│ ████ ████ ████ ████ ████ │CANCL│ZOOM│
└─────────────────────────────────┘
```
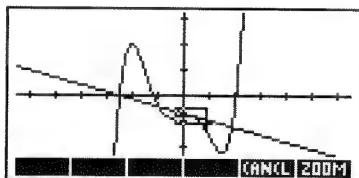
Step 2: Execute the zoom, move the cursor near the local maximum point, and find an extremum.

ZOOM
▶ or ◀ as needed
FCN EXTR

```
┌─────────────────────────────────┐
│                  │               │
│           ─────────────          │
│        ───           ──          │
│      ──                 ─         │
│    ──                    ─        │
│                           ──      │
│                             ──    │
│                               ─   │
│ EXTRM: (.159483706477,-3.910918662!│
└─────────────────────────────────┘
```
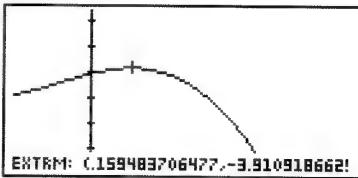
Step 3: Return to the stack. Notice that each of the analytic functions put a labeled result onto the stack.

(CANCEL) (several times)

```
┌─────────────────────────────────┐
│3:                  Slope: .072   │
│2: TanLine: 'Y=-1.401…            │
│1: Extrm:                         │
│   (.159483706477,-3.…            │
│ VECTR MATR LIST HYP REAL BASE    │
└─────────────────────────────────┘
```

6-16 Plotting Equations and Analyzing Graphs

Lesson 28: Areas Under Curves

The AREA command in the PICTURE FCN menu finds a definite integral based on the current function. That is, it calculates and displays the area between the current function and the x-axis between two x-values you designate.

Example: Find the area under the current polynomial $(X^5 + X^4 - 5X^3 - 2X^2 + X - 4)$ between $x = -2.2$ and $x = -1.5$.

Step 1:   Reopen PLOT and redraw the polynomial.

⟦→⟧ ⟦PLOT⟧ ⟦▼⟧ ⟦▶⟧
3 ⟦+/−⟧ ⟦ENTER⟧ 3 ⟦ENTER⟧ ⟦▶⟧
12 ⟦+/−⟧ ⟦ENTER⟧ 12 ⟦ENTER⟧
ERASE DRAW
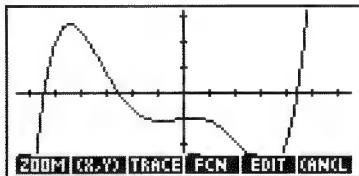
Step 2:   Use Decimal Zoom to force each horizontal pixel to be equivalent to 0.1 units. Then move the cursor to $x = -2.2$ (the lower limit), and mark it. Note the use of the multiplication key ⟦×⟧ to "mark" a cursor position.

ZOOM ⟦NXT⟧ ⟦NXT⟧
ZDECI (X,Y)
⟦▶⟧ or ⟦◀⟧ as needed
⟦×⟧ (to mark the cursor position)
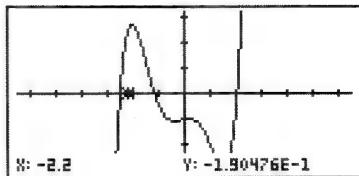
Step 3:   Find the selected area. Note that for finding the numerical integral, the shading is for display purposes only and is entirely optional.

⟦▶⟧ (7 times)
⟦NXT⟧ (to redisplay the menu)
FCN AREA
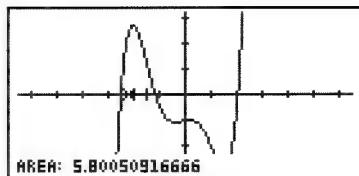
Step 4:   *Optional.* Shade the area between the current function and the x-axis, and between the x-values represented by the mark and the cursor. Note that the shading is for display purposes only and is entirely optional to the process of finding the area under a curve.

(NXT) (to redisplay the menu)
SHADE

7
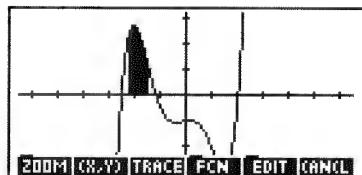
Calculus, Statistics and Advanced Mathematics

This chapter shows you a few examples of the high-powered mathematics of which the HP 48 is capable. The examples you'll explore are:

▶ Finding symbolic derivatives.

▶ Finding symbolic integrals.

▶ Entering and summarizing data.

▶ Performing a regression analysis on a set of data.

▶ Solving the initial-value problem for a first-order differential equation.

▶ Plotting a phase plane for a differential equation.

▶ Finding the eigenvalues of a matrix.

Lesson 29: Finding Derivatives

Example: Find the slope of $f(x) = 5x^2 - \frac{6}{x}$ at $x = \frac{1}{2}$.

Step 1: Select Differentiate from the SYMBOLIC menu.

⬐⟶ SYMBOLIC ▼
...OK...

```
▒▒▒▒▒▒▒▒DIFFERENTIATE▒▒▒▒▒▒▒▒
EXPR: ███████████████████
VAR:
RESULT: Symbolic

ENTER EXPRESSION
 EDIT │CHOOS│     │STEP│CANCL│ OK
```

Step 2: Enter the expression.

⬐ (EQUATION) 5 (α)X (yˣ) 2 (▶)
(−) 6 (÷) (α)X
(ENTER)

```
▒▒▒▒▒▒▒▒DIFFERENTIATE▒▒▒▒▒▒▒▒
EXPR: ▓5*X^2-6/X▓
VAR:
RESULT: Symbolic

ENTER EXPRESSION
 EDIT │CHOOS│     │STEP│CANCL│ OK
```
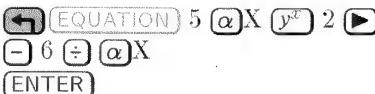
Step 3: Enter the variable of differentiation.

(▼) (α)X (ENTER)

```
▒▒▒▒▒▒▒▒DIFFERENTIATE▒▒▒▒▒▒▒▒
EXPR: '5*X^2-6/X'
VAR: X
RESULT: ▓Symbolic▓

CHOOSE RESULT TYPE
     │CHOOS│     │STEP│CANCL│ OK
```

Step 4: Because you want a *numerical* derivative, make sure that Numeric is displayed in the RESULT: field.

(+/−) (if necessary)

```
▒▒▒▒▒▒▒▒DIFFERENTIATE▒▒▒▒▒▒▒▒
EXPR: '5*X^2-6/X'
VAR: X
RESULT: ▓Numeric▓
VALUE:
CHOOSE RESULT TYPE
     │CHOOS│     │STEP│CANCL│ OK
```
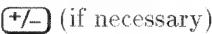
Step 5: Enter the value at which you are evaluating the derivative, and calculate.

⊙ .5 (ENTER) ⠀⠀OK⠀⠀

```
1:                    29
VECTR MATR LIST HYP REAL BASE
```

Example: Find the symbolic derivative of $f(x) = 5x^2 - \frac{6}{x}$.

Step 1: Reselect Differentiate... from the SYMBOLIC menu and repeat the previous example, making sure to set the RESULTS: field to Symbolic.

(→) (SYMBOLIC) (▼) (ENTER)
(▼) (α)X (ENTER)
(+/−) (if necessary)

```
▒▒▒▒▒▒▒▒DIFFERENTIATE▒▒▒▒▒▒▒▒
EXPR: '5*X^2-6/X'
VAR: X
RESULT:Symbolic

CHOOSE RESULT TYPE
      CHOOS      STEP CANCL  OK
```

Step 2: Calculate the symbolic derivative.

⠀OK⠀

```
1:         '5*(2*X)+6/X^2'
VECTR MATR LIST HYP REAL BASE
```

Lesson 30: Finding Integrals

The examples in this lesson illustrate how to find numerical and symbolic integrals.

Example: Evaluate:

$$\int_0^1 (2X - 6X^4 + 5)dX$$

Step 1: Select Integrate from the SYMBOLIC menu.

Step 2: Enter the integrand.

Step 3: Enter the variable and limits of integration.

Step 4:   Change the RESULT: field to Numeric, if necessary.

⟨+/−⟩ (if necessary)

```
▓▓▓▓▓▓▓▓▓▓ INTEGRATE ▓▓▓▓▓▓▓▓▓▓
EXPR: '2*X−6*X^4+5'
VAR: X      LO: 0        HI: 1
RESULT:Numeric
NUMBER FORMAT: Std

CHOOSE RESULT TYPE
▓▓▓▓ CHOOS ▓▓▓▓▓▓▓▓▓▓ CANCL  OK
```
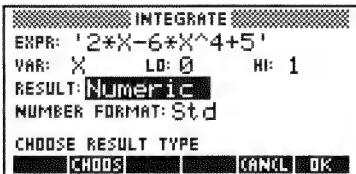
Step 5:   When you want to perform a numeric integration, the
number of digits in current display mode is used to estimate
an accuracy factor. Higher accuracy factors require more
calculation time. Std yields the highest accuracy factor, and
Fix 0, Sci 0, or Eng 0 the lowest. Change to Sci 5 and
compute the integration.

⟨▼⟩⟨+/−⟩ (until Sci is displayed)
⟨►⟩ 5 ⟨ENTER⟩ OK

```
1:                    4.80000E0
VECTR MATR LIST  HYP  REAL BASE
```

Press ⟨←⟩⟨MODES⟩ FMT STD to restore Std display mode.

Example: Evaluate:

$$\int_0^a (a^2 X - X^3) dX$$

(If you've already used the variable *a* in another
example, you need to purge *a* before continuing. Press
⟨→⟩⟨MEMORY⟩⟨α⟩⟨←⟩A ⟨NXT⟩ PURG OK .)

Step 1:   Select Integrate and enter the integrand.

⟨→⟩⟨SYMBOLIC⟩ OK
⟨←⟩⟨EQUATION⟩⟨α⟩⟨←⟩A ⟨yˣ⟩ 2
⟨►⟩⟨α⟩X ⟨−⟩⟨α⟩X ⟨yˣ⟩ 3
⟨ENTER⟩

```
▓▓▓▓▓▓▓▓▓▓ INTEGRATE ▓▓▓▓▓▓▓▓▓▓
EXPR: 'a^2*X−X^3'
VAR:        LO:        HI:
RESULT: Symbolic


ENTER EXPRESSION
 EDIT CHOOS ▓▓▓▓▓▓▓▓ CANCL  OK
```

Step 2:   Enter the variable and limits of integration.

▼ (α)X (ENTER)
0 (ENTER)
(α)(←)A (ENTER)

```
▓▓▓▓▓▓▓▓▓INTEGRATE▓▓▓▓▓▓▓▓▓
EXPR: 'a^2*X-X^3'
VAR: X      LO: 0      HI: a
RESULT: Symbolic

CHOOSE RESULT TYPE
▐▐▐▐CHOOS▐▐▐▐▐▐▐▐CANCL▐OK
```

Step 3:   Turn on symbolic mode, if necessary, and evaluate the
           integral.

(+/−) (if necessary)
OK

```
RAD
{ HOME }
1:  '-(X^(3+1)/((3+1)*∂
    X(X)))+a^2*(X^2/2)|
    (X=a)-(-(X^(3+1)/((
    3+1)*∂X(X)))+a^2*(X
VECTR▐MATR▐LIST▐HYP▐REAL▐BASE
```

Step 4:   Simplify the expression by collecting terms until it doesn't
           simplify further.

(←)(SYMBOLIC) COLCT COLCT
COLCT

```
1:                '.25*a^4'
COLCT▐EXPA▐ISOL▐QUAD▐SHOW▐TAYLR
```

Lesson 31: Data and Statistics

Statistical data for the HP 48 are represented by matrices. Such a matrix contains a row for each *data point* and a column for each *variable* measured at that point.

	var$_1$	var$_2$	. . .	var$_m$
point$_1$	x_{11}	x_{12}	. . .	x_{1m}
point$_2$	x_{21}	x_{22}	. . .	x_{2m}
$\vdots$	$\vdots$	$\vdots$		$\vdots$
point$_n$	x_{n1}	x_{n2}	. . .	x_{nm}

The Statistics application uses the data stored in the *current statistical matrix*, stored in reserved variable ΣDAT. You change the current statistical matrix each time you work with a different set of data.

Example: Find the mean and standard deviation for each variable in the following set of sample data. The two variables are the consumer price index (CPI) and the producer price index (PPI) for the United States over a 5-year period:

Year	CPI	PPI
1	9.1	9.2
2	5.8	4.6
3	6.5	6.1
4	7.6	7.8
5	11.5	19.3

Step 1: Select Single-var... from the STAT menu.

```
▓▓▓SINGLE-VARIABLE STATISTICS▓▓▓
ΣDAT: ████████████    COL: 1
TYPE: Sample
  _MEAN      _STD DEV  _VARIANCE
  _TOTAL     _MAXIMUM _MINIMUM

ENTER STATISTICAL DATA
 EDIT CHOOS          CANCL  OK
```
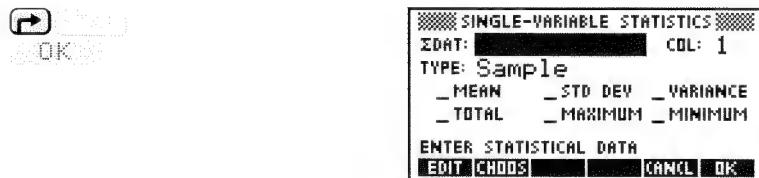
Step 2: If you had already entered this data set (as a matrix) and stored it with a name, pressing CHOOS would allow you to select it now for statistical analysis. However, to enter new data, you must create a new data matrix now. Call up the MatrixWriter and enter the data.

[←][MATRIX]
9.1 [ENTER] 9.2 [ENTER] [▼]
5.8 [SPC] 4.6 [SPC] 6.5 [SPC] 6.1
[SPC] 7.6 [SPC] 7.8 [SPC] 11.5
[SPC] 19.3 [SPC]
[ENTER] [ENTER]

```
▓▓▓SINGLE-VARIABLE STATISTICS▓▓▓
ΣDAT: [[ 9.1 9.2..  COL: 1
TYPE: Sample
 _MEAN      _STD DEV  _VARIANCE
 _TOTAL     _MAXIMUM _MINIMUM

ENTER STATISTICAL DATA
 EDIT CHOOS          CANCL  OK
```
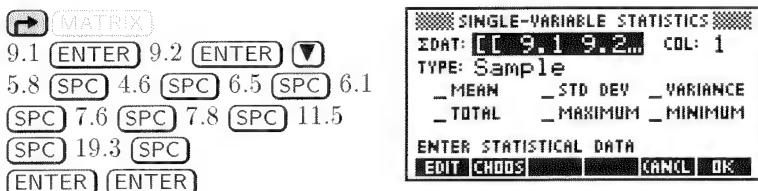
Step 3: By default the column for which you will be calculating the mean and standard deviation shows 1 (i.e. the CPI data). Accept the default for now. Put a check-mark next to each statistic that you want to calculate, and press OK to calculate. The labeled results are put onto the stack.

[▼][▼] ✓CHK [◀] ✓CHK
OK

```
2:                   Mean: 8.1
1: Std Dev:
     2.27266363547
VECTR MATR LIST  HYP  REAL BASE
```
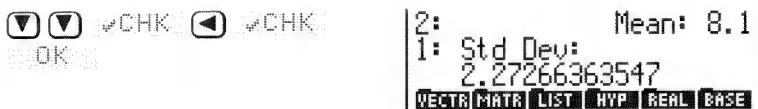
Step 4: Repeat the procedure for the PPI, this time changing the column number to 2.

[←][STAT] OK
[▶] 2 [ENTER] [▼] ✓CHK [◀]
✓CHK
OK

```
2:                   Mean: 9.4
1: Std Dev:
     5.7995689495
VECTR MATR LIST  HYP  REAL BASE
```

Lesson 32: Regression Analysis of Paired Data

The HP 48 can fit any one of four statistical models to a set of data pairs. Once again the data must be in the ΣDAT matrix.

Example: Using the same data as the previous example, calculate the correlation and covariance between the CPI and PPI variables using the best-fitting regression model (of the four available). Then predict the PPI value for a CPI value of 8.5 using the calculated model.

Step 1: Open the STAT application and select Fit Data....
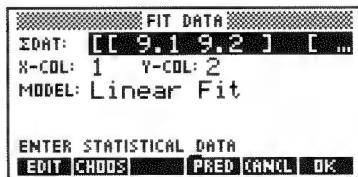
Step 2: Check your regression options. The correct data is in ΣDAT already. The two variables that you wish to compare, CPI and PPI, are located in columns 1 and 2 of ΣDAT, respectively, so make sure that X-COL: contains 1 and Y-COL: contains 2. Change the regression model type to Best Fit.
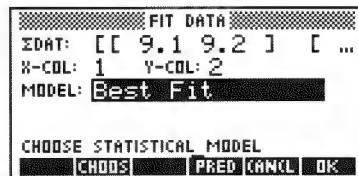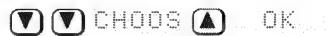
Step 3:   Enter the target value for CPI (*x*-variable) and predict the PPI value (*y*-variable) using the best-fitting model. Note that the HP 48 determined that an `Exponential` model has the best fit (i.e the highest correlation coefficient of any of the four models).

PRED ▲ 8.5 ENTER PRED

```
▒▒▒▒▒▒▒PREDICT VALUES▒▒▒▒▒▒▒
ΣDAT:  [[ 9.1 9.2 ]  [ ...
X-COL: 1    Y-COL: 2
MODEL: Exponential Fit
X: 8.5         Y: 9.09314...
ENTER DEP VALUE OR PRESS PRED
  EDIT                        PRED
```

Step 4:   Put the computed regression model, along with the correlation coefficient and covariance, onto the stack.

CANCEL OK

```
RAD
{ HOME }
3: '1.2346138924*EXP(...
2: Correlation: .9872...
1: Covariance:
    1.21332685284
VECTR MATR LIST HYP REAL BASE
```

Lesson 33: Differential Equations

The examples in this lesson show you how to solve an initial-value problem for a first-order differential equation and how to plot a phase plane solution of a differential equation.

Example: Find $y(t)$ for $t = 8$ where $Y'(T) = \frac{1}{1+T^2} - 2Y^2$ and $Y(0) = 0$. Find the answer to within an error tolerance of 10^{-7}.

Step 1: Select `Solve diff eq...` in the SOLVE application.

(→) SOLVE (▼) (ENTER)

```
░░░░░░░░ SOLVE Y'(T)=F(T,Y) ░░░░░░░░
F:
INDEP: X   INIT: 0      FINAL:6.5
SOLN: Y    INIT: 0      FINAL:
TOL:.0001  STEP: Dflt   _STIFF
ENTER FUNCTION OF INDEP AND SOLN
EDIT CHOOS            INIT+ SOLVE
```

Step 2: Enter the right hand expression ($\frac{1}{1+T^2} - 2Y^2$) into F. Notice that the variables appear in the menu as soon as you begin the command line, so that you can use them as typing aids.

(') 1 (÷) (←) (') 1 (+) (α) T (y^x)
2 (▶) (-) 2 (×) ··· Y ··· (y^x) 2
(ENTER) (α) T (ENTER)

```
░░░░░░░░ SOLVE Y'(T)=F(T,Y) ░░░░░░░░
F:   '1/(1+T^2)-2*Y^2'
INDEP: T   INIT: 0      FINAL:6.5
SOLN: Y    INIT: 0      FINAL:
TOL:.0001  STEP: Dflt   _STIFF
ENTER INITIAL INDEP VAR VALUE
EDIT                 INIT+ SOLVE
```

Step 3: Check the remaining fields. You are using the default values for the solution (Y) variable name as well as for the initial values (0 and 0). You can use the default value for STEP: (the iterative step size) as well. Change the final value for T to 8, and the tolerance to 1E-7.

(▶) 8 (ENTER)
(▼) 1 (EEX) 7 (+/-) (ENTER)

```
░░░░░░░░ SOLVE Y'(T)=F(T,Y) ░░░░░░░░
F:   '1/(1+T^2)-2*Y^2'
INDEP: T   INIT: 0      FINAL:8
SOLN: Y    INIT: 0      FINAL:
TOL:.000... STEP: Dflt  _STIFF
ENTER INITIAL STEP SIZE
EDIT                 INIT+ SOLVE
```

Step 4: Highlight the FINAL: solution field and solve the problem.

▲ ▶ SOLVE

```
▒▒▒▒▒▒▒SOLVE Y'(T)=F(T,Y)▒▒▒▒▒▒▒
F:    '1/(1+T^2)-2*Y^2'
INDEP: T  INIT: 0    FINAL:8
SOLN: Y  INIT: 0    FINAL:▓.12▓
TOL:.000,, STEP: Dflt  _STIFF

PRESS SOLVE FOR FINAL SOLN VALUE
▐EDIT▐▬▬▬▬▬▬▬▬▬▐INIT+▐SOLVE▐
```

Step 5: Exit the SOLVE application and view the solution on the stack.

(NXT) OK

```
2: Tolerance: .0000001
1: Solution:
   .123076920969
▐VECTR▐MATR▐LIST▐HYP▐REAL▐BASE▐
```

Example: Plot the solution of the previous differential equation (Y) with respect to time (T) from $t = 0$ to $t = 8$.

Step 1: Open the PLOT application and select the Diff Eq plot type. Notice that, as a shortcut for choosing a plot type, typing D brings up the next (or only) plot type beginning with the letter D.

⮕ PLOT ▲
(α) D

```
▒▒▒▒▒▒▒▒PLOT Y'(T)=F(T,Y)▒▒▒▒▒▒▒
TYPE: ▐Diff Eq▐▐   ∢:Deg
F:    '1/(1+T^2)-2*Y^2'
INDEP: T  INIT: 0    FINAL:8
SOLN: Y  INIT: 0    _STIFF

CHOOSE TYPE OF PLOT
▐▬▬▐CHOOS▐▬▬▬▐OPTS▐ERASE▐DRAW▐
```

Step 2: The proper equation is still in the F: field. Change the final value to 8 if necessary.

▼ ▼ ▶ ▶ 8 (ENTER)

```
▒▒▒▒▒▒▒▒PLOT Y'(T)=F(T,Y)▒▒▒▒▒▒▒
TYPE: Diff Eq     ∢:Deg
F:    '1/(1+T^2)-2*Y^2'
INDEP: T  INIT: 0    FINAL:8
SOLN: ▐Y▐ INIT: 0    _STIFF

ENTER SOLUTION VAR NAME
▐EDIT▐▬▬▬▬▬▬▐OPTS▐ERASE▐DRAW▐
```

Step 3: Change to the Plot Options form to set the tolerance (10^{-7}), the horizontal plotting range (-1 to 8), and the vertical plotting range (-0.5 to 1). Other option values are the same as the defaults for this example.

OPTS 1 (EEX) 7 (+/-) (ENTER)
(▼) 1 (+/-) (ENTER) 8 (ENTER) (►)
.5 (+/-) (ENTER) 1 (ENTER)

```
▓▓▓▓▓▓▓▓PLOT OPTIONS▓▓▓▓▓▓▓▓
TOL: .000₋₋ STEP: Df 1t   ✓AXES
H-VAR: 0     H-VIEW: −1      8
V-VAR: 1     V-VIEW: −.5     1
H-TICK: 10   V-TICK: 10   ✓PIXELS

ENTER HORIZONTAL TICK SPACING
 EDIT                    CANCL  OK
```

Step 4: Set the option changes, erase the picture display, and draw the plot.

OK ERASE DRAW
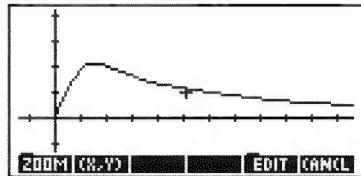
Lesson 34: Linear Algebra

The HP 48 includes a number of useful linear algebra commands in the MTH MATRIX command menu. You will find commands for finding the determinant, inverse, transpose, rank, trace, spectral radius and norm, condition number, eigenvalues, and eigenvectors of a matrix. Additionally, you can compute the reduced row echelon form of a matrix and decompose appropriate matrices using any of several different decompositions (LU, LQ, QR, Schur, and single-value).

While you should consult chapter 14 of the *HP 48G Series User's Guide* for details about these commands, try the following example as a sample.

Example: Find the eigenvalues and eigenvectors of matrix A:

$$A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$$

Step 1:   Using the Matrix Writer, enter matrix A onto the stack.

[→] MATRIX
2 [+/−] [ENTER] 2 [ENTER] 3 [+/−]
[ENTER] [▼] 2 [ENTER] 1 [ENTER]
6 [+/−] [ENTER] 1 [+/−] [ENTER] 2
[+/−] [ENTER] 0 [ENTER]
[ENTER]

```
1: [[ -2 2 -3 ]
    [ 2 1 -6 ]
    [ -1 -2 0 ]]
VECTR MATR LIST HYP REAL BASE
```

Step 2:   Find the eigenvectors and eigenvalues of the matrix.

[MTH] MATR [NXT] EGV

```
2: [[ 1 .5 1 ]  [ -.2…
1:              [ -3 5 -3 ]
RSD  EGV EGVL →DIAG DIAG→
```

The eigenvectors are shown on level 2 and the eigenvalues on level 1. The related command, EGVL, computes only the eigenvalues.

8

Special Features

This chapter shows you how to:

▶ Transfer objects between two HP 48s using the infrared port.

▶ Find and use an equation set from the built-in Equation Library.

▶ Attach, detach and use libraries.

Lesson 35: Transferring Objects Via Infrared

The HP 48 has both wired and infrared serial input/output ports to allow you to transfer objects to and from other devices—printers, computers, and other HP 48s.

Serial transfer requires the optional Serial Interface Cable (see your HP dealer). Infrared transfer between two HP 48s, can be accomplished quickly and easily without any additional equipment.

To transfer an object from one HP 48 to another:

1. Line up the infrared ports by lining up the ▲ marks (near the Hewlett-Packard logo just above the display). The calculators should be no farther apart than 2 inches.
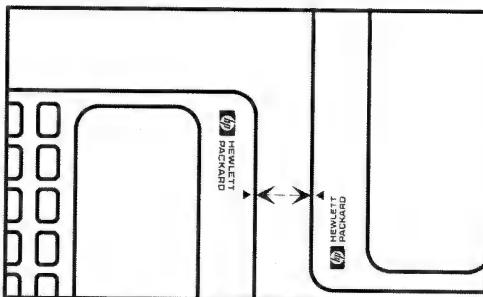
2. **Receiver.**
   - Change to the directory where the new object is to be stored.
   - Press ⟦↱⟧⟦I/O⟧.
   - Select Get from HP 48 from the menu and press ⟦OK⟧.
3. **Sender.**
   - Press ⟦↱⟧⟦I/O⟧.
   - Select Send to HP 48... from the menu and press ⟦OK⟧.
   - Type or CHOOS the name of the object to be transferred into the NAME field.
   - Press ⟦SEND⟧.

Lesson 36: Using an Equation Set from the Equation Library

The Equation Library is a collection of equations and commands that enable you to solve simple science and engineering problems. The library consists of more than 300 equations grouped into 15 technical subjects containing more than 100 problem titles. Each problem title contains one or more equations that help you solve that type of problem.

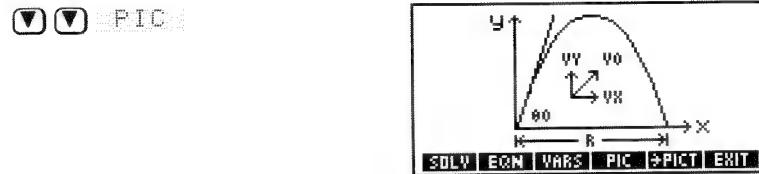**Example:** Examine the equation set for Projectile Motion.

Step 1: Fix the display to 2 decimal places and then open the EQ LIB application. (If SI ■ and UNIT■ aren't flagged with small squares, press each of the corresponding menu keys once.)

(⏎) MODES (α)F (▶) 2 (ENTER)
(ENTER)
(⏎) EQ LIB

```
▓▓▓▓▓▓▓ EQUATION LIBRARY ▓▓▓▓▓▓▓
Columns and Beams
Electricity
Fluids
Forces and Energy
Gases
Heat Transfer            ↓
 SI ▪ ENGL UNIT▪        QUIT
```

Step 2: Select the Motion subject area and open its catalog.

(α)M (▼) (ENTER)

```
▓▓▓▓▓▓▓▓▓▓ MOTION ▓▓▓▓▓▓▓▓▓▓
Linear Motion
Object in Free Fall
Projectile Motion
Angular Motion
Circular Motion
Terminal Velocity        ↓
 SOLV EQN VARS PIC →STK EXIT
```

Step 3: Select Projectile Motion and look at the diagram that describes the problem.

(▼)(▼) PIC

```
┌─────────────────────────┐
│ y↑                       │
│      vy  v0              │
│     ↖↗                   │
│      ↘→vx                │
│   θ0                     │
│  │       →x              │
│ │←── R ──→│              │
│ SOLV EQN VARS PIC →PICT EXIT │
└─────────────────────────┘
```

Step 4: View the five equations in the `Projectile Motion` set. All five are used interchangeably in order to solve for missing variables (see the next example).

```
EQN   NXEQ   NXEQ
NXEQ  NXEQ
```

```
5 OF 5 ☓

       v0²
R = ───── · SIN(2·θ0)
        9

SOLV NXEQ VARS  PIC  →STK EXIT
```

Step 5: Examine the variables used by this equation set.

```
VARS
```
▲ and ▼ as needed

```
▒▒▒▒▒▒PROJECTILE MOTION▒▒▒▒▒▒
x0: init x-position
x:  final x-position
y0: init y-position
y:  final y-position
θ0: initial angle
v0: initial velocity ↓
SOLV EQN  VARS  PIC  →STK EXIT
```

Now try using this equation set to answer a question or two.

Example: You estimate that an average professional goalkeepers can punt a soccer ball a distance (R) of 65 meters downfield at an elevation angle (θ_0) of 50 degrees. At what velocity (v_0) do they kick it? How high is the ball halfway through its flight? How far could they drop kick the ball if they used the same kicking velocity, but changed the elevation angle to 30 degrees? (Ignore the effects of drag on the ball.)

Step 1: Start solving the problem.

```
SOLV
```

```
▒▒▒▒▒▒▒PROJECTILE MOTION▒▒▒▒▒▒▒
4:
3:
2:
1:
  X0    X    Y0    Y    θ0
```

Step 2: Enter the known values. Define *x0* and *y0* as 0. Notice that the menu labels turn black as you store values.

```
0  X0    0  Y0    50
    θ0    (NXT) 65     R
```

```
R: 65_m

4:
3:
2:
1:
[ V0 ][ VX ][ VY ][ T ][ R ][ ALL ]
```

Step 3: Solve for the velocity, v_0. Notice that pressing the left-shifted version of a variable's menu key causes the HP 48 to solve for it.

```
(⇦)    V0
```

```
2:
1:        v0: 25.44_m/s
[V0■][ VX ][ VY ][ T ][R■][ALL]
```

Step 4: Recall the range, *R*, divide by 2 to get the halfway distance, and enter that as the *x*-coordinate. Notice that pressing the right-shifted version of a variable's menu key causes the HP 48 to recall its value to the stack. (The small square next to the R on the menu label indicates that it was used in the previous calculation.)

```
(⇨)    R ■
2 (÷) (NXT) (NXT)    X
```

```
x: 32.50_m

4:
3:
2:
1:        v0: 25.44_m/s
[X0 ][ X ][ Y0 ][ Y ][ θ0 ][ ]
```

Step 5: Solve for the height *y*. Notice that the HP 48 finds values for other variables as needed (shown by the small squares) in order to solve for the specified variable.

```
(⇦)    Y
```

```
1:           y: 19.37_m
[X0■][X■][Y0■][Y■][θ0■][ ]
```

Step 6: Enter the new value for the elevation angle (30 degrees), store the previously computed initial velocity (v_0), and then solve for R.

30 80 ▪
(SWAP) (NXT) V0
⬅   R
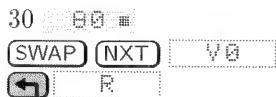
| 1: | | | | | R: 57.16_m |
| V0 ▫ | VX | VY | T | R ▪ | ALL |

To attach a library to user memory manually:

1. Change to the directory to which you want to attach the library.
   - To access the library from all directories, move to *HOME*.
   - To limit access, move to the desired directory. The library will be available only in this directory and its subdirectories.
2. Enter the *library identifier* for the library—it has the form ⠶*port*⠶*number*, where *number* is a unique number associated with the library.
3. Press ◀ (LIBRARY) (NXT) ATTAC.

There is no limit to the number of libraries that can be attached to the HOME directory. However, every other directory is limited to *one* attached library.

To use a library that is attached in the current path:

1. Press ▶ (LIBRARY). This brings up the Library Catalog, a menu of all currently available libraries. This is similar to the way the (VAR) key brings up a menu of all variables in the current directory.
2. Press (NXT) or ◀ (PREV) as necessary to find the desired library.
3. Press the menu key corresponding to the desired library to open the menu of commands contained in the library.

To detach a library from a directory:

1. Change to the directory where the library is attached.
2. Enter the unique library number for the library you are detaching.
3. Press ◀ (LIBRARY) DETAC to detach it from the current directory.
4. Press ▶ (LIBRARY) and examine the menu. The library should have disappeared. If it didn't, it may be attached to a *second* directory in the current path.

To purge a library from memory:

1. Make sure that the library is no longer attached to any directory. Detach it, if necessary.
2. Type in the library identifier (*port*⠶*number*) for the library you want to remove and press (ENTER) (ENTER) ▶ (RCL).
3. Press ◀ (MEMORY) NEWO to remove any temporary references to the library.
4. Press (SWAP) ◀ (PURG) to remove the library from memory.

Lesson 37: Adding and Using Libraries

A *library* is a collection of pre-programmed commands that act as extensions to the built-in command set. The HP 48 does *not* have the built-in capacity to create libraries, but it can *install* and *use* libraries that have been created elsewhere (on other computers) and transferred to the HP 48.

If you have an HP 48G model, you must download a library into your machine using either the infrared port (from another HP 48) or the serial port (from a personal computer). Refer to chapter 27 of *HP 48G Series User's Guide* for details about serial port transfer. If you have an HP 48GX model, you have the additional option of installing a plug-in card containing the library into one of the two expansion card slots. Refer to chapter 28 of *HP 48G Series User's Guide* for more details about plug-in cards.

Libraries, like any other object, can be placed on the stack or stored in user memory. However, libraries *cannot be used* while stored on the stack or in user memory.

To use a library, it must be:

■ *Stored in port memory* (Port 0 for the HP 48G or Ports 0-32 for the HP 48GX). All libraries that are distributed on plug-in cards are already in port memory whenever the card is installed in its slot. Libraries that are downloaded into the current directory must be moved into port memory by you.

■ *Attached to a directory.* Most libraries are self-attaching—that is, they automatically attach themselves to the HOME directory as soon as you turn on the HP 48 again after installing them in port memory. Others will need to be explicitly attached by you.

To store a library into port memory manually:

1. Put the library object on the stack. (Note its number and name.)
2. Enter the port number for storing the library (0, 1, 2, ... 32).
3. Press (STO).
4. Optional: Purge the original library object from user memory.

9

If Things Go Wrong ...

Whenever you run into problems—either following examples in this manual or solving your own problems—you can use these hints to get back on track.

Lesson 38: Error Messages

The HP 48 indicates that it can't do something by sounding a beep (if the beeper is enabled) and displaying a error message. A complete list of these messages and their meanings can be found in Appendix B of the *HP 48G Series User's Guide*. Clear the message by pressing (CANCEL) (or any other key).

Here are the meanings of four of the more common error messages:

Bad Argument Type. You tried to do something to or with an object that isn't valid for that kind of operation. For example, dividing by a text string causes this error.

Too Few Arguments. You tried to do something without supplying the calculator with enough stack arguments. For example, executing (+) with only one number on the stack causes this error.

Invalid Card Data. The HP 48 cannot read data stored on a plug-in card you inserted. However, you will also see this message whenever a RAM card contains ports you've never used. Press (◄) (LIBRARY) (NXT) PINIT to initialize all available RAM ports. This does not affect data already stored on the card.

Undefined Name. The HP 48 attempted to execute a command that requires numeric arguments and found a symbolic argument it could not convert into a number. If the command *should* accept symbolic arguments, then perhaps the Numeric Results flag (-3) is set (press (►) (MODES) FLAG to check). Clear it and try again.

Lesson 39: Troubleshooting

If the HP 48 is stuck in an unfamiliar state:

■ Press (CANCEL) several times, until you see the normal stack display.

To undo a mistake:

■ To remove the last result and get back the original data, press 🠒 (UNDO) (above the (EVAL) key).
■ To clear stack level 1, press (DROP).
■ To clear the entire stack, press (CLEAR).
■ To retrieve a previous command line you executed (so you can change it or execute it again), press 🠒 (CMD) (above the (+/-) key).
■ To keep the last result *and* get back the original data, press 🠒 (ARG).

To reset all calculator operating modes without erasing memory:

■ Press (🠔) (MODES) FLAG (NXT) RESET.

If the calculator doesn't respond when you press the keys:

1. Press (CANCEL) several times.
2. If the keyboard is "locked," or the **Σ** annunciator won't turn off, perform a *system halt*:
   a. Press and hold (ON).
   b. Press and release the "C" menukey.
   c. Release (ON). The empty stack display should appear.
3. If the HP 48 doesn't respond to the system halt from the keyboard, try to halt the system directly (without using the keyboard), as described on page 5-17 of *HP 48G Series User's Guide*.
4. If the problem still exists, perform a *memory reset*. (See page 5-17 of *HP 48G Series User's Guide*.)

If these steps fail to restore operation, the calculator requires service.

To reset the calculator (and erase all memory):

1. *If there's anything in memory you want to keep, don't reset the calculator.*
2. Press and hold (ON).

3. At the same time, press the left and right menu keys (A and F),
   then release them.
4. Release the (ON) key.
5. Press NO.

The above steps also erase the contents of a plug-in RAM card—but
only if its RAM is merged with the calculator's main memory.

If the calculator won't turn on:

1. Press and release (ON).
2. If the display is still blank, hold down (ON) and press (+) several
   times until characters become visible; then release (ON). If no
   characters appear in the display, check for too light of a display.
3. If nothing appears in the display, install three new AAA batteries,
   as described under "Changing Batteries" in Appendix A of
   HP 48G Series User's Guide. Then repeat the previous steps.
4. If changing the batteries did not solve the problem, turn the HP 48
   over. Remove the top right (as you face the bottom of the machine)
   rubber foot. You should see a small hole with the letter R next to
   it. Insert the end of an ordinary metal paper clip into the hole as
   far as it goes. Hold for one second and remove. Press (ON). Repeat
   the previous steps.
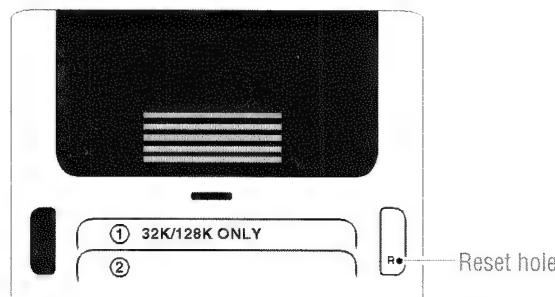
5. If all of this doesn't work, your calculator needs repair. Contact the
   HP Calculator Support department (see the inside back cover).

If you suspect that your calculator is malfunctioning:

1. Run the self-test:
    a. Turn on the calculator.
    b. Press and hold (ON).
    c. Press and release the "E" menukey.
    d. Release (ON). The diagnostic self-test tests the internal ROM and RAM, and generates various patterns in the display. The test repeats continuously until you perform a system halt.
2. Halt the self-test (system halt):
    a. Press and hold (ON).
    b. Press and release the "C" key (the key with C next to it).
    c. Release (ON). The empty stack display should appear.

If the self-test indicates an internal ROM or RAM failure (if IROM OK and IRAM OK are not displayed), the calculator requires service.

If the calculator passes the self-test, you may have made a mistake operating the calculator. Reread appropriate sections of the documentation and "Answers to Common Questions" in Appendix A of the *HP 48G Series User's Guide*.

Contacting Hewlett-Packard

For Information about Using the Calculator. If you have
questions about how to use the calculator that are not covered in
this guide, first check the table of contents, the subject index,
and "Answers to Common Questions" in appendix A of the
HP 48G Series User's Guide. If you can't find an answer in
either manual, you can contact the Calculator Support
Department:

> Hewlett-Packard
> Calculator Support
> 1000 N.E. Circle Blvd.
> Corvallis, OR 97330, U.S.A.
> (503) 715-2004 (Mon.–Fri., 8:00am–3:00pm Pacific time)
> (503) 715-3628 FAX

For Hardware Service. See appendix A of the *HP 48G Series
User's Guide* for diagnostic instructions and information on
obtaining service. *But, before you send your unit for service,
please call HP Calculator Support at the number listed below.*

> Hewlett-Packard
> Corvallis Service Center
> 1030 N.E. Circle Blvd., Bldg. 11
> Corvallis, OR 97330, U.S.A.
> (503) 715-2004 (HP Calculator Support)

If you are outside the United States, see appendix A in the
User's Guide for how to locate your nearest service center.

HP Electronic Information Service. This service provides
information on HP 48 calculators and is free of charge—you pay
only for the phone call or Internet service. There are two ways to
connect:

- **via modem:** (503)715-4448. It operates at 2400/9600/14400
  baud, full duplex, no parity, 8 bits, 1 stop bit.
- **via the Internet:** Access as hpcvbbs.external.hp.com
  (192.6.221.13) using telnet, ftp, or World-Wide-Web browser
  (http://hpcvbbs.external.hp.com/hp48g.html).

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